VENTILATION

SEMINAR

PHILIP MORRIS, INC. T.T.G.

and

PHILIP MORRIS U.S.A.

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INTRODUCTION

In the pages that will follow this brief introduction, several people at Philip Morris U.S.A. have attempted to compile a collection of related information on the ventilation of cigarettes. We have assembled data from a wide variety of sources, trying to provide helpful analysis and/or explanations. We have been responsible for selecting the information we felt was most pertinent to the subject. In talking to some of our colleagues, we found a wide diversity of opinions as to the content of the material included in the presentation. We had a purpose for including everything that is contained in the seminar.

In the course of writing the presentation, materials were included on not simply ventilating cigarettes, but on lowering deliveries in general. This is because they are not mutually exclusive subjects. We will let you be the judge as to the relevence of this to the ventilation overview. Obviously, it is impossible for this seminar to be everything to everybody.

Many of the subjects that will be covered contain grey areas. Points on a graph cannot simply be plucked-off to use for designing a new cigarette or predicting deliveries. These graphs are useful for estimating a starting point for design or for predicting trends. Experiments are no substitute for testing your own product. The information in this presentation is not intended to supercede the need to consult with design personnel in Richmond for specific questions on design or production. You should, however, learn what questions to ask, who to ask, what materials you will need, what machinery, what problems you may encounter, and so on.

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As mentioned, this seminar is essentially a collection of work done by many people. We have done no experiments, improved no machinery, developed no new theories. We have, however, saved you the trouble of extensive research. Through discussions, phone calls, consultations, etc., we have tried to assemble all of the relevent information concerning ventilation. A patent abstract is also included for those who wish to further research the subject. We make no claims to be the final word. A complete bibliography is included at the end of the paper.

Charlie Altizer and Chris Goodwin wrote and will present the first section, "VENTILATION TECHNOLOGY, THEORY AND HISTORY", Gary Bolanowski wrote and will present the second section, "QUALITY ASSURANCE FOR VENTILATED PRODUCTS". Billy Christopher will handle the third section, "PRODUCTION OF VENTILATED CIGARETTES".

Before beginning I would like to specifically thank the principle contributors to the seminar, without whose help this would not have been possible:

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VENTILATION SEMINAR

I. VENTILATION TECHNOLOGY, THEORY AND HISTORY

A. Definitions (Charlie Altizer)

1. What is Ventilation?

2. Terminology Used in the Presentation

   a. Paper Industry Terminology
   b. Tobacco Industry Terminology

3. Static State vs. Dynamic State

B. Low Tar Market Trends (Chris Goodwin)

1. U.S.

   a. The Industry
   b. Government Action
   c. Delivery Trends
   d. Ultra-Low Tar Cigarette Trends
   e. Ventilated Cigarette Trends
      1. General
      2. Philip Morris
      3. Industry Comparison

2. International

   a. Industrialized Countries
      1. Delivery Trends
      2. Government Action
   b. Developing Countries
      1. Delivery Trends
      2. Government Action
   c. Summary

C. Alternatives for Achieving Lower Deliveries (Chris Goodwin)

1. Introduction

2. Tobacco Modifications
   a. Genetic/Blend
   b. Modified Tobaccos
   c. Cut Rag Width

3. Cigarette Modifications
   a. Weight and Density
   b. Length
   c. Circumference
   d. Moisture
   e. Cigarette Paper

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VENTILATION SEMINAR

I. VENTILATION TECHNOLOGY, THEORY AND HISTORY (continued)

C. Alternatives for Achieving Lower Deliveries (continued)

4. Filter Modifications
   a. Tow
      1. Cross-Section
      2. Fiber Denier
   b. Dimension
   c. Charcoal
   d. Gimmicks
   e. Additives
   f. Ventilation

5. Conclusion

D. Paper (Chris Goodwin)

1. Cigarette
2. Tipping
3. Plug Wrap

E. Mathematical Model for Calculating Dilution (Charlie Altizer)

1. Explanation of Model
2. Comparison of Calculated to Measured Dynamic State
3. Comparison of Calculated to Measured Dynamic & Static State

F. Effects of Ventilating Cigarettes (Charlie Altizer)

1. Smoke Formation
2. Mechanisms of Ventilation
   a. Experiments
   b. Conclusions
3. Reduction of Various Smoke Components
   a. Particulate Phase
      1. TPM
      2. Tar
      3. Nicotine
      4. Nicotine/Tar
      5. H_2O
   b. Gas Phase
      1. CO
      2. NO
      3. Other
4. Changes in Cigarette Parameters
   a. Puff Count
   b. RTD
5. Summary

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VENTILATION SEMINAR

I. VENTILATION TECHNOLOGY, THEORY AND HISTORY (continued)

G. Types of Ventilation (Charlie Altizer & Chris Goodwin)
   1. Cigarette Paper
      a. Inherently Porous
      b. Perforated
      c. Programmed
   2. Porous Tipping Paper
   3. Hauni Pin
   4. Molins CVS
   5. Electric Spark Perforation
      a. Background
      b. Component Modifications
      c. Principles of Operation
   6. Mechanical
      a. Background
      b. Machine Operation
   7. Laser
      a. Philip Morris
      b. Hauni On-Line
      c. Macro vs Micro
   8. Typical Laser/ESP Capabilities
   9. Industry Practices

H. Effects of Perforation Variations (Chris Goodwin)
   1. Size of Holes/Number of Holes
   2. Location of Holes
   3. Number of Rows
   4. Industry Practices

I. Cigarette Design (Chris Goodwin)
   1. Introduction
   2. Design Philosophy
      a. General Guidelines
      b. Design Steps
   3. Hypothetical Delivery Reductions
      a. Full Flavored - Unventilated to Ventilated
      b. Full Flavored to Low Tar - Both Ventilated
      c. Low Tar to Ultra-Low Tar - Both Ventilated
   4. Summary

J. Ventilation Systems Patent Abstracts (Chris Goodwin)

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II. QUALITY ASSURANCE FOR VENTILATED PRODUCTS (Gary Bolanowski)

A. General Principals of Dilution

1. Definition

2. Why Have Dilution?
   a. Control tar-nicotine-CO
   b. Maintain flavor

3. What affects Dilution?
   a. Plug wrap
   b. Tipping paper
   c. Filter RTD
   d. Cigt. RTD

4. Types of Perforation
   a. Electrostatic
      1. How
      2. Pros
      3. Cons
      4. % Dilution Range
      5. Comments

   b. Mechanical pre-perf
      1. How
      2. Pros
      3. Cons
      4. % Dilution Range
      5. Comments

   c. Hauni Pin
      1. How
      2. Pros
      3. Cons
      4. % Dilution Range
      5. Comments

   d. Laser
      1. How
      2. Pros
      3. Cons
      4. % Dilution Range
      5. Comments

   e. Max S Laser
      1. How
      2. Pros
      3. Cons
      4. % Dilution Range
      5. Comments

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II. QUALITY ASSURANCE FOR VENTILATED PRODUCTS

B. Direct Materials Conversion Plant (DMCP)

1. Overview of Direct Materials Conversion Plant

   a. Pallets - unperforated
   b. Perforators
   c. Q.A.
   d. Pallets restacked perforated
   e. Warehousing

2. Quality Assurances Function

   a. Objective
   b. Parameters Checked
      1. Pressure Drop
      2. Band Position
      3. Visual Examinations

   c. Q.A. Technician Responsibilities
      1. Determine disposition/quality of perf'd paper
      2. Communicate with production personnel
      3. Proper recording of data
      4. Proper use and calibration of equipment

   d. How does QA Operate
      1. Sampling - ESP vs Laser
      2. Pressure drop procedure - Tipper
      3. Band inspection - optical comparator
         a. Position
         b. Width
      4. Visual Observations
         a. Bobbin damage
         b. Palletizing

3. Q.A. Test Equipment

   a. Tipper PDI - Pressure
   b. Optical Comparator - Band Width
   c. Discussion of control chart use.
   d. Outline tipper calibration
   e. Control charts - PD

C. Handling Dilution in Production Environment

1. Digital Dilution Inst.

   a. Calibration
   b. Proper Inserts

2. Dilution Testing

   a. Sampling
   b. Frequency

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II. QUALITY ASSURANCE FOR VENTILATED PRODUCTS (continued)

C. Handling Dilution in Production Environment (continued)

2. Dilution Testing (continued)

c. Recording Data
d. Median Plotting
e. Method
f. Data Evaluation - Include (Chart Explanation)

3. What to Investigate When Dilution Problems Occur

a. Dilution gauge calibration
b. Cigt. parameters
c. Filter parameters
d. Tipping paper
e. Glue application area - on tipper
f. Cork drum/roll hand
g. Patch inspection - Detail
    1. Centered
    2. Sample preparation
    3. Skip gap roller

D. Properties of Material That Should Be Checked When Dilution Problems Occur

1. Plug Wrap

a. Porosity
b. Gauges
c. Types

2. Tipping Paper

a. Pressure Drop
b. Band Positions
c. Gauges

3. Cigarette Paper

a. Porosity
b. Gauges
c. Effect on dilution

4. Vendor Defects

a. Pin holes, thin spots, thin paper
b. Light table

5. Tipping Adhesive

a. Viscosity - Viscometer
b. Tip to tip - important

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II. QUALITY ASSURANCE FOR VENTILATED PRODUCTS (continued)

E. Types of Instruments

1. Porosity/Permeability Gauges

a. Filtrona 1110 MAN
b. Filtrona PPM 100
c. Digital Porosity Meter
d. Greiner

2. DMCP Test Equipment

a. PDI (Tipper)
b. Optical Comparator

3. Cigarette Inspection Gauges - Dilution

a. DDI
b. Filtrona VOM 100

4. Cigarette Inspection Gauges - Circumference

a. Techmet 50 (Lasermike)
b. Filtrona TLG 100

5. Adhesive Testing

a. Brookfield RVF (Viscometer)
b. Mettler PK 300 (Balance)

III. PRODUCTION OF VENTILATED CIGARETTES (Billy Christopher)

A. Filter Manufacture Using Porous Plug Wrap

1. Hot Melt
2. Machine Considerations
3. Machine Modifications
4. Filter Rod Specification Changes

B. Skip Gap Rollers

1. Design
2. Size
3. Timing - Patch Test
4. Tipping Matchup
5. Patch Parameters
6. Ordering

C. Cigarette Manufacture

1. Tipping Roll Hand Setting
2. Tipping Paper Pressure Drop
3. Problems and Corrective Measures

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III. PRODUCTION OF VENTILATED CIGARETTES (continued)

D. Equipment
1. Tipping Units
a. PA-8
b. MAX 3
c. MAX 80
d. MAX S

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A. Definitions

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Sunday/February 27th		
5:30 p.m. - 7:00 p.m.	Informal Reception	Holiday Inn South Room 301
Monday/February 28th		
8:30 a.m. - 12:15 p.m.	1st Session Conference Room	Holiday Inn South 2nd Floor
1:15 p.m. - 5:00 p.m.	2nd Session	
	INFORMAL BUFFET	
Tuesday/March 1st		
8:30 a.m. - 12:15 p.m.	1st Session Conference Room	Holiday Inn South 2nd Floor
1:15 p.m. - 5:00 p.m.	2nd Session	
Wednesday/March 2nd		
GROUP A 8:30 a.m. - 12:15 p.m.	1st Session Conference Room	Holiday Inn South 2nd Floor
1:15 p.m. - 5:00 p.m.	2nd Session	Operations Center R & D
GROUP B 8:30 a.m. - 12:15 p.m.	1st Session Training Center	Conference Room
1:15 p.m. - 5:00 p.m.	2nd Session Training Center	Conference Room
Thursday/March 3rd		
GROUP A 8:30 a.m. - 12:15 p.m.	1st Session Training Center	Conference Room
1:15 p.m. - 5:00 p.m.	2nd Session Training Center	Conference Room
GROUP B 8:30 a.m. - 12:15 p.m.	1st Session Conference Room	Holiday Inn South 2nd Floor
1:15 p.m. - 5:00 p.m.	2nd Session	Operations Center R & D
Friday/March 4th		
9:00 a.m. - 12:00 Noon	1st Session Operations Center	Conference Room A3W-1

LUNCHEON - OPERATIONS CENTER

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I. VENTILATION TECHNOLOGY & THEORY

A. DEFINITIONS

1. Ventilation is the process by which atmospheric air is introduced into the mainstream smoke between the coal and the mouth end of the cigarette. The end result of ventilating a cigarette is the dilution of the mainstream smoke with outside air. Ventilation may be accomplished, that is, diluting air may be introduced by porous or perforated tobacco column wrapper or through perforated or porous tipping in combination with porous or perforated plugwrap (or a non wrapped acetate filter). Slide A-1 shows an illustration of a vented filter cigarette with the sources of air flow. Slide A-2 shows the flow relationship that total flow Ft is equal to Fu, flow upstream of the vents, plus Fv, flow through the vents. So ventilation V is equal to flow thru vents/ total flow or Fv/(Fv + Fu).

Since the total standard air flow rate is 1050 cc/min, ventilation is also defined as the % of 1050 cc/min. total flow that enters through the vents. (The standard air flow for static state measurements is based on a 2 sec. puff at 17.5 cc/sec. This gives a static state continuous flow of 1050 cc/min.)

The flow rate through the tobacco column upstream of the vents is always less than the total exit flow. This will be discussed later, and explains some of the unusual characteristics of vented cigarettes.

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2. Terminology Used in the Presentation

a. Tobacco Industry Terminology

Air Dilution - The addition of atmospheric air to mainstream smoke; the % of a 1050 cc/min. rate of flow that is drawn through the ventilation system.

Air Flow (Standard) - In the static state 1050 cc/min, or in the dynamic state 17.5 cc/sec for a 2 sec duration.

Air Permeability of Paper - The ability of paper to transmit the flow of air. Cigarette paper typically is measured in Greiner Porosity, Perforated tipping in pressure drop, and porous plug wrap in Coresta. These porosities are defined later.

Burning Zone Temperature - The temperature of a burning cigarette at the point where the coal meets the paper; during puffing 850-900°C.

Butt Length - Length of cigarette remaining after smoking a cigarette on a smoking machine. In the case of CI data, tipping + 3 mm.

Cambridge Filter - A trapping device used universally in smoking machines for collection of particulate matter. It is made of CM 113A fiberglass sheet. It shall collect at least 99% of all particles over .3mm in diameter and 99.2% of all .1 mm diameter particles at a flow rate of 28 linear feet/min., and a maximum pressure drop not exceeding 93 mm of water at 28 FPM and contain not more than 5% acrylic type binder.

CO/CO_2 - Carbon monoxide and carbon dioxide.

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Combustion - The interaction of tobacco with oxygen to produce heat and light. Tobacco is oxidized inefficiently, resulting in distillation, pyrolosis and pyrosynthesis products as well as expected gases CO_2, H_2O and NO.

Condensable Gas Phase - The fraction of mainstream smoke which passes through the cambridge filter and can be trapped is a glass tube at a specific temperature designed to trap the gases.

Continuous Glue Free Line - A dry area of tipping with no tipping adhesive that covers porous or perforated plug wrap with ventilation holes.

CORESTA - Centre de Cooperation for the Researchers Scientific Relatives au Taboc.

Deliveries (U.S. Defined)

Full Flavor - Greater than 15 mg FTC Tar

Low Tar - 15 mgs FTC Tar or less

Ultra Low Tar - 6 mgs/cigt FTC Tar or less

Distillation Products - Leaf components that are transferred into the smoke stream essentially unchanged, such as nicotine.

Dry Smoke Condensate - The weight of crude smoke condensate after deduction of its water content.

Dynamic State - The lit cigarette as puffs are taken.

ESP - Electric Spark or Electrostatic Perforation

Filtration Efficiency - The weight percent of incoming smoke or smoke component that is removed by the filter. % Filtration efficiency = $\frac{A - D}{A}$ where A is the available and D is the delivered smoke or smoke component.

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F.T.C. Tar - Total Particulate Matter minus nicotine and water. Reported in mg/cigt. FTC Tar (mg/cigt) = A - (B + C) where A = TPM, B = Nicotine in TPM and C = Water in TPM.

Gas Phase - The phase of cigarette smoke that passes through a cambridge filter; consists of permanent gases and vapors, including oxygen, nitrogen, carbon monoxide, carbon dioxide, methane, ethane, butane, low boiling hydrocarbons, alcohols, esters, carboxyls, phenols, et. al.

Greiner Cigarette Paper Porosity - The time in sec. required for 50 cc of air to pass through .786 in^2 of paper. The higher the number, the lower the porosity of the paper.

Hot Melt Adhesives - 100% solids adhesives based on thermo plastic polymers. They are applied in the molten state and set or form a bond on cooling. They are particularily valuable in the sealing of filter rod seams when porous plug wrap is used.

Mainstream Smoke - In a closed system, mainstream smoke is the smoke issuing from the mouth end of a cigarette. In a free smoking situation, it is the smoke that is drawn from the mouth end of a cigarette during puffing.

Particulate Phase (TPM) - The phase of cigarette smoke retained on a cambridge pad consists of solids and condensed droplets from .2 - .4 micron, with maximum size of 1.0 - 1.5 micron.

Perforation - Holes introduced into cigarette paper, tipping paper or plugwrap by ESP, Laser, or Mechanical means to increase the air permeability of the particular paper.

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Permeability of Plugwrap - ml of air/min/cm^2 that passes through the plugwrap.

Porosity - The time taken for a volume of air to pass through a given area of paper. Some measurements are expressed in terms of volume/time unit/area of paper.

Pressure Drop (RTD) - The pressure developed by a cigarette or filter when air is pulled through it at 17.5 cm^3/sec or at 1050 cm^3/min.

Puff Count - The number of puffs taken on a cigarette smoked to a prescribed butt length.

Puff Duration - The fixed time lapse per puff taken on a cigarette smoked to a prescribed butt length under standard smoking condition. Standardized at 2.0 $\pm$ .2 sec.

Puff Frequency - The number of puffs per unit of time on a smoking machine. Standardized at 1 puff per 60 $\pm$ 1 sec.

Puff Number - A whole number that describes a given puff on a cigarette in terms of the total number of puffs taken on a cigarette.

Puff Velocity - The velocity of a 35 cc puff for a 2 sec. duration on a smoking machine.

Pyrolysis - The thermal rupture of a leaf component into smaller fragments.

Pyrolysis Zone - The area behind the burning zone where thermal decomposition takes place in the absence of oxygen.

Pyrosynthesis - The recombination of fragments resulting from pyrolysis to form new smoke components.

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Sidestream - In a closed smoking system (for analytical purposes), sidestream is the smoke that does not issue from the mouth end of a cigarette, but rather from the burning end. In a free smoking situation it is all the smoke issuing from any part of the cigarette except the mouth end.

Skip Gap-Gumming - Refers to a tipping adhesive application method in which the glue roller is designed to skip adhesive application in the areas where the perforation bands are located, with the exception of the area of the tipping overlap.

Smoke Aerosol Velocity - The flow rate of the smoke aerosol through the tobacco column and filter tip.

Smoking Machine - A mechanical device allowing reproducible cigarette smoking under standard conditions in a manner designed to approximate human smoking behavior. Automatic Smoking Machine any type of Restricted Smoking Machine capable of taking a 2 sec 35 mm puff once per min. Restricted means that the unlit ends are not open to the atmosphere between puffs.

Static Burning Rate - The amount of time required for a cigarette rod to burn 40 mm under static conditions; the rate at which a cigarette smoulders in the absense of drafts or puffing action.

TPM (Total Particulate Matter) - The portion of the smoke collected on a cambridge filter pad. TPM is considered to be tar + nicotine + water collected on the cambridge pad.

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b. Paper Industry Terminology

Abaca - a leaf fiber commonly used in tea bag paper, gaskets, bags, etc. It is known for its fiber length and strength. Also known as Manila fiber or hemp.

Basis Weight - The weight in pounds of a ream (usually 500, but sometimes 480 sheets) of paper cut to its basic size. It is now much more common to express it in g/m^2 (TAPPI standard).

Bast Fibers - The bast fibers used in the paper industry are obtained from the outer part, or bast, of the stem of dicotyledonous plants.

Calcium Carbonate - A calcite product used for coatings and fillers in paper. It is white with varying particle size. It imparts good burning properties to cigarette paper. As a filler, it improves brightness, opacity, and ink receptivity.

Cellulose - The basic raw material for papermaking, occuring in the fibers of most plants and trees. Wood is the principle source. The cellulose content of commonly used sources varies from 40% for wood (in general) to 98% for cotton.

China Clay - A term originally applied to the beneficiated kaolin mined in Europe, but now applied to all beneficiated kaolin.

Esparto Grass - Short fibered grass from the monocotyledonous plant group. Popular for years in Europe for medium and high class papers of a soft, impressionable nature.

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Fibrillation - A term commonly associated with refining of pulp. It results in the loosening of threadlike elements from the fiber wall to provide greater surface for forming fiber-to-fiber bonds.

Filler Clay - A clay added to the papermaking furnish prior to the formation of the sheet on the paper machine.

Flax - Linen is obtained by retting the fiber strands from the outer part of the flax plant for textile purposes. A pulp mixture of the chopped flax seed plant stalk, containing both bast and shive fibers, is more commonly used for the manufacture of cigarette paper.

Furnish - The mixture of various materials that are blended in the stock suspension from which paper or board is made. The chief consituents are the fibrous material (pulp), sizing materials, wet-strength or other additives, fillers and dyes.

Hemp - Bast fiber of hemp plant with similar structure and size as flax. Commonly used in cigarette paper in Europe.

Kaolin - an inexpensive, white, soft, non-abrasive hydrated aluminum silicate commonly used as a filler and paper coating. It increases the opacity of the sheet.

Opacity - TAPPI opacity is the ratio of the reflectance of a single sheet over a black background, R_O, divided by the reflectance of the same sheet backed by an arbitrary white body of absolute reflectance 0.89.

Shive Fibers - The shorter cells from the woody core of the stem of dicotyledonous plants.

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Sizing - The process in which a chemical additive provides paper and paperboard with resistance to wetting and penetration, usually by acqueous liquids. Rosins and waxes are common sizing agents.

TAPPI - Technical Association of the Pulp and Paper Industry

Tensile Strength - The maximum tensile stress developed in a tension test carried to rupture under prescribed conditions, expressed as force per unit width of test specimen, usually kg/cm, or a similar form.

Titanium Dioxide - The white oxide of titanium, TiO_2. It is useful as a filler and pigment because of its color, high brightness, high refractive index and opacity.

3. Static State vs Dynamic State

Normally in the cigarette industry, ventilation of cigarettes is reported in the unlit or static state, as opposed to the lit or dynamic state. One advantage is this is more practical in producing uniform cigarettes. However, dilution is underestimated, since the coal in the dynamic state contributes substantially to draw resistance. This enhances dilution. All reported Philip Morris measurements are made in the static state.

Both methods determine the volumetric flow through the vents of the filter; however, the two methods differ in objective and procedure. The Steady-State method determines the dilution of an unlit cigarette while maintaining a constant flow rate of 1050 cc per minute, and defines Filter Dilution as the percent of the 1050 cc per minute continuous-exit flow that enters the cigarette through the dilution system of the filter. The Dynamic

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method determines the dilution of a lit cigarette as puffs are taken, and defines Filter Dilution as the percent of the total puff that enters the cigarette through the dilution system of the filter.

Slide A -3 shows the effect of the burning cone on cigarette ventilation, which serves to illustrate differences that are seen between the static and the dynamic states. High temperature and rapidly expanding gases give the burning coal a resistance to air flow. This increases the pressure up stream of the vents which increases the ventilation level.

Cigarette A and cigarette B ventilation levels were measured lit and after extinquishing in inert nitrogen. The unlit value was less than the lit value for the same length of unburned tobacco rod. At higher ventilation as noted in the slide the relative increase is less.

Slide A-4 shows some general relationships which point out that as pressure drop upstream of the vents increases that ventilation increases. This slide further illustrates the difference between static and dynamic states, since as previously mentioned formation of the coal increases pressure drop up stream of the vents. Note also the fact that as the tipping and plugwrap permeability increase that ventilation increase. The relative pressure drop upstream of the vents has increased while the relative pressure drop of the vents has decreased.

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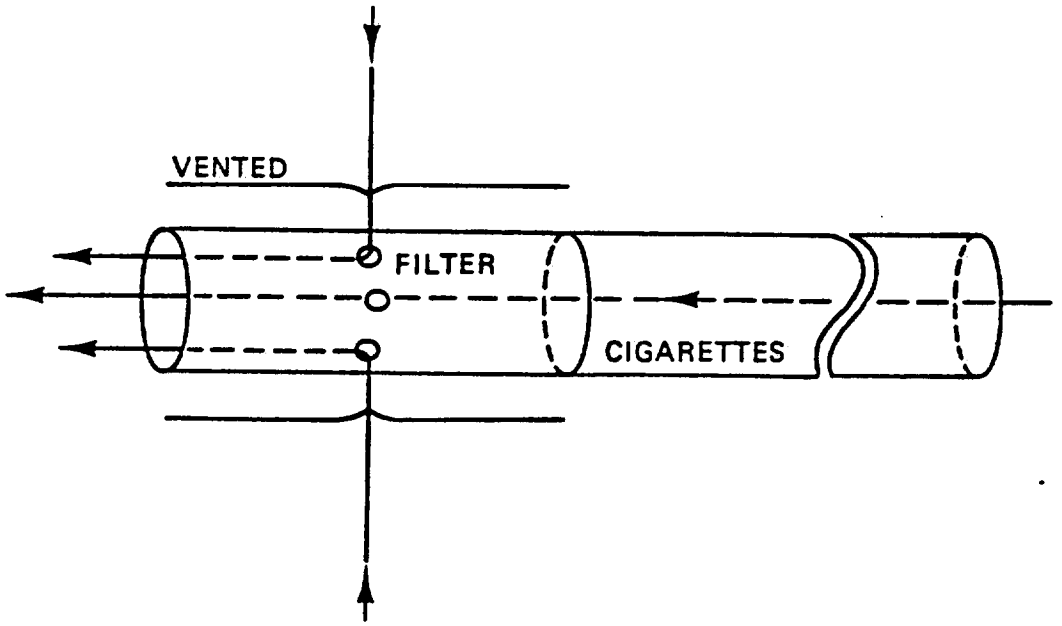

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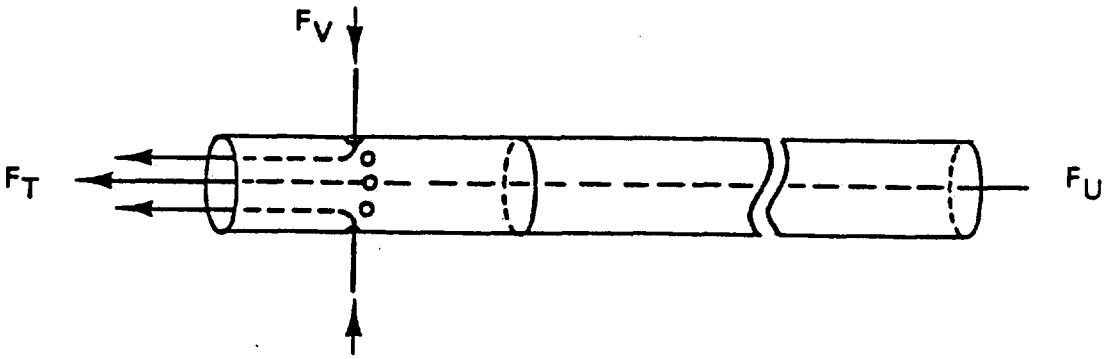
VENTILATION



$$V = F_V/F_T = F_V/(F_V + F_U)$$

DEFINITIONS

V – VENTILATION – FRACTION OF THE PUFF THAT ENTERS THROUGH THE VENTS

F_V – VOLUMETRIC FLOW RATE THROUGH THE VENTS

F_U – VOLUMETRIC FLOW RATE UPSTREAM OF THE VENTS

F_T – TOTAL FLOW THROUGH THE CIGARETTE (17.5 CC/SEC)

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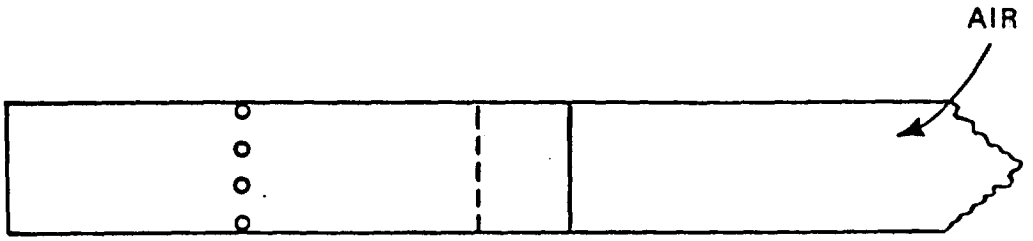
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF BURNING CONE ON VENTILATION



CIGARETTES	VENTILATION, % UNLIT	LIT	INCREASE, %
A	60	70	14.3
B	28	36	22.2

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

SOME GENERAL RELATIONSHIPS FOR CIGARETTE PARAMETERS AND VENTILATION

VENTILATION INCREASES AS THE PRESSURE DROP UPSTREAM OF THE VENTS INCREASES.

1. INCREASE IN TOBACCO COLUMN PRESSURE DROP (DECREASE IN CIGARETTE PAPER PERMEABILITY AND INCREASE IN TOBACCO COLUMN DENSITY.)
2. INCREASE IN FILTER PRESSURE DROP.
3. INCREASE IN FILTER LENGTH UPSTREAM OF THE VENTS.

VENTILATION INCREASES AS TIPPING AND PLUGWRAP PERMEABILITY INCREASES.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

B. LOW TAR MARKET TRENDS

1. U.S.

a. The Industry

The U.S. cigarette industry has long been a six company market, with imports of little or no consequence. The past 10 years have seen Philip Morris climb out of a three way race with B & W and American to contest R.J. Reynolds for first place in the domestic market. This period of remarkable growth has resulted in a virtual tie for the lead. No other cigarette company has even half of the sales volume of the two leaders. There are many reasons why Philip Morris has managed to grow so rapidly, despite a mere 1-3% annual growth rate of the overall domestic market. One of the most important of these is their commitment to anticipate change. A strong Research and Development Department keeps the company abreast of technology. With more interest groups applying pressure to the cigarette industry each year, the level of sophistication in cigarette manufacturing is constantly rising. The U.S. market is so dynamic today that any failure to adapt to the tides of change can do irreparable damage to a company's market share. American Tobacco Company was the largest U.S. manufacturer in the 1950's. When filter cigarettes were introduced in 1954, American failed to foresee or accept the demand for filtered products. American is now the fourth largest domestic manufacturer, with less than 10% of the market.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

The fate of American Tobacco should serve as a warning to any firm content to maintain the status quo. Anticipation is the key to a smooth, successful operation.

b. Government Action

The most influencial single government action on the U.S. cigarette industry was undoubtedly the 1964 Surgeon General's report calling cigarette smoking a health hazard. Per capita consumption of 4345 units in 1963 has never been equaled, and has showed a steady decline since 1973. Although tar deliveries were already declining due to filter sales, this report vastly accelerated the trend. More than that, it was the turning point that set the tone for all future cigarette production. Health warnings on packs followed, then a ban on T.V. advertising. Tar and nicotine levels were regularly published. Gas phase data followed that. This same pattern is being repeated in many other countries. Other legislative restrictions have periodically been proposed. In 1975, Senator Frank Moss proposed that interstate transport of cigarettes containing over 21 mg of tar be banned, on the grounds they were a hazardous substance. In 1977, Senators Kennedy and Hart forwarded a bill to tax cigarettes based on tar and nicotine content. These measures were never passed, but they illustrate the type of government opposition that makes it prudent for the industry to police themselves.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Although tar and nicotine are under the spotlight now, the publishing of cigarette CO tables in March 1981, indicates a new era has begun. The possibility other gas phase elements may follow must be considered.

c. Delivery Trends

The average U.S. cigarette tar delivery peaked at 38 mg in 1956. By 1964, when the Surgeon General's report surfaced, it had already dropped all the way to 23 mg. In 1979 it fell below 15 mg, the defined upper limit of a low tar cigarette. The 1981 average stood at 12.6 mg. Nicotine levels peaked in 1955 at 2.69 mg per cigarette. It stood at only .95 mg per cigarette in 1981.

The development of the cellulose acetate filter by Eastman Kodak was principally responsible for the above mentioned decrease in deliveries over the past 25 years. This innovation revolutionized a market that was 99% non-filtered cigarettes into one that is currently 92% filters. Even by 1968, three quarters of all cigarettes sold were filter products. Cellulose acetate combined the advantages of excellent machinability and low cost with effective smoke filtration properties. Perhaps the most important feature was CA's ability to do all this without unfavorably altering the taste of the tobacco. Although there are still other filter materials used, cellulose acetate is the material of choice in virtually every country in the world.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Government and consumer pressure have combined in this country to create the low tar cigarette. The filtered cigarette has allowed this transition to be possible. Government standards define a low tar cigarette as one having 15 mg tar or less. There is as yet no nicotine standard.

Graph B.-2 shows the growth of low-tar cigarette sales in the U.S. over the past 10 years as compared to total cigarette sales. Yearly total sales growth has been essentially static, usually 0-2% per year. While total sales have only increased about 13% in the last 10 years, low-tar sales have soared an incredible 1113%! Volume has gone from 31 billion units in 1972 to 376 billion in 1981. Graph B.-3 portrays this in market share terms. Low-tar cigarettes only accounted for 2% of sales in 1968. They were 60% of sales in 1981. Low tar cigarette sales growth largely parallel the growth of filter cigarettes a decade earlier. It is conceivable the low tar market could capture 90% of total sales before the end of the decade, if not sooner. They are already growing much faster than predictions of only a few years ago.

Ironically, it was American Brands, the big loser in the filter revolution, who introduced the first low tar cigarette, CARLTON. Lorrilard followed close behind in 1964 with its entry, TRUE. R.J. Reynolds did not want to be left out, so they introduced DORAL in 1969 and the highly successful VANTAGE in 1970.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Philip Morris sought to perfect a low tar cigarette that would overcome the main shortcoming of low tar cigarettes, a lack of taste. When introduced in 1975, MERIT took off like a whirlwind. Its fantastic growth was a phenomenom unequaled then or now.

While all of the above mentioned brands found their niche in the market, many others did not. Over the period 1971 to 1976, a total of 106 new brands went to test market. Most of these did not get beyond that stage, but it is a good illustration of the type of market conditions that are typical of a market in transition.

d. Ultra-Low Tar Cigarette Trends

The ultra-low tar cigarette is something that evolved in the mid 1970's from the low tar cigarette, a type of "one-upmanship". It is defined as a cigarette with 6 mg tar or less. CARLTON, along with TRUE, were once again the pioneers in this field. They both evolved into ultra-low tars over the years to keep pace with their image. CARLTON has always maintained it is the lowest tar and nicotine cigarette on the market. After a decade of sales that hovered around a .1% market share, sales accelerated in 1973. By 1977, CARLTON had captured 1.6% of the total market, 2.5% by 1981. It was the fastest growing cigarette in the industry for a time. The other manufacturers took note of the change.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

The commitment to produce ultra-low tars has resulted in a steady rise in the sale of ultra low-tar cigarettes. They have climbed from less than 2% market share in 1972 to almost 10% in 1981. This translated into 62 billion units in 1981. Projections for 1985 are in the range of 22%. Though it is possible to manufacture low-tar cigarettes in the upper end of the range without employing dilution, it is virtually impossible to make any saleable ultra low-tar cigarette without utilizing ventilation of some form.

Due to the fierce competition, the cost of promoting a new brand has become astronomical. Budgets of $40 million plus are not uncommon. Advertising on ultra low-tars alone exceeded $300 million in 1981, an increase of 50% over 1980. This accounts for 40% of the entire 1981 cigarette advertising budget. The race to be the lowest has resulted in NOW, CARLTON and CAMBRIDGE all claiming that status. With variations of these cigarettes down to essentially 0 tar (.01 mg claimed), bottom has been hit. The limited success of these tarless cigarettes has caused manufacturers to seek out a higher, more acceptable delivery level.

Table B.-5 traces the top 10 selling U.S. brands over the past four years. This table will not agree with the usual top 10 tables generally produced, which include all brand extensions. I have compiled this myself to group like cigarettes and equal deliveries. For our purposes, grouping menthol and ultra low-tar brand extensions together with

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

full flavor cigarettes tells us nothing for tar delivery trend analysis. Even four years ago, only 2 of the top 10 selling cigarettes were classified as low-tar. This number doubled in 1979, rose to 5 in 1980, and became a majority (7) in 1981. As you can see, this was accomplished through both the growth of low-tar brands and the lowering of deliveries of former full flavored brands. Table B.-6 shows how the full flavored cigarettes that have been in the top 10 have undergone a decrease in their deliveries. You can see that all full flavor brands shown have witnessed a steady decline in sales, some more rapid than others. Only Marlboro 100's have held their own. By contrast, VANTAGE and MERIT are the only low-tar brands not to show a steady sales growth. However, the introduction of ultra low-tar brand extensions by both brands corresponds to the decreasing sales. That is, it is highly likely many former VANTAGE and MERIT smokers merely switched to their respective Ultra Light versions, further confirming the rapid conversion towards a low-tar market.

Virtually all new brands introduced into the U.S. now are low or ultra low-tar. It is doubtful anyone will risk the capital to market anything new over 15 mg tar. Accompanying this change is the ventilation trend. Practically all new cigarettes are ventilated, and most existing cigarettes are being converted.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

e. Ventilated Cigarette Trends

1. General

M. O. Schurr first described the reduction of deliveries through dilution in 1960. Ventilation theory has expanded vastly since then, as has the corresponding utilization of ventilation in cigarette production. As tar levels have been decreasing rapidly over the past 10 years, the number of cigarettes employing ventilation have increased. The use of dilution has become a necessity to reach many of these low and ultra low-tar levels. Graph B.-7 illustrates just how rapidly the change has come about. In 1975, only 7% of all cigarettes sold in the U.S. were ventilated. This tripled to 20% only 2 years later, and soared to half the total market by 1980. Only 18 months after that time, 80% of the cigarette sales were ventilated by one means or another. As 8% of the remaining 20% are non-filter cigarettes, you can see that only 12% of filter cigarette sales are unventilated.

2. Philip Morris

Philip Morris first attempted to ventilate a cigarette about 1960 Three slits ahead of the filter made SPUD our initial attempt at ventilation. The idea lay dormant until 1970, when Hauni Pin ventilation was used to perforate Marlboro 120 mm. Alpine and Marlboro Menthol 85 mm followed in September 1971. Table B.-8 shows the dilution history of all current production Philip Morris domestic cigarette brands. Frequent minor

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

changes in dilution targets occasionally must be made in the initial stages of brand production, in order to meet practical machinability standards. These are not all shown here, but should be kept in mind. It is not always possible to attain the dilution levels specifications and reach specified delivery levels at the same time. Therefore, dilution levels will have to be modified at this point to meet the delivery levels.

This list of ventilated cigarettes includes all of the filter cigarettes currently produced by Philip Morris. Ventilation levels vary from 8 - 95% at this time, encompassing a wide range of deliveries. A number of cigarettes have maintained the same dilution target over the years while others have switched four or five times. Dilution level changes are much easier to implement to lower deliveries than are the alternatives to dilution. That undoubtedly accounts for much of the reason for the widespread usage of dilution today.

3. Industry Ventilation Comparison

Table B.-9 shows the market for ventilated cigarettes broken down by company. Philip Morris and R.J. Reynolds have converted virtually all of their filter cigarette production to diluted cigarettes. Lorrilard has almost completed the transition, being 94% complete. American is currently diluting 57% of their filter production. Brown and Williamson and Liggett and Myers have only converted a little more than one third of their

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

filter production to ventilated brands. It is likely that the latter three companies will eventually convert the rest of their filter production over time, although little has been done towards that aim over the past few years.

2. INTERNATIONAL

a. Industrialized Countries

1. Delivery Trends

A number of other countries have been accompanying the U.S. in the trend towards low tar cigarettes. These are most notably Canada, Western Europe (mainly Northern Europe), Japan, and Australia. These countries are generally more technologically able to address the challanges of low tar cigarette construction than the rest of the world. Their governments have also exerted more pressure to make the change. Other countries have begun the transition, but these areas most closely parallel the U.S. market.

Outside of the U.S., Canada has one of the highest percentages of low tar smokers. They accounted for 46% of total cigarette sales in 1981. Six of the top ten selling brands are still full-flavored cigarettes, but most of those have slowly lowered their tar deliveries since 1976. If you recall, this is the same pattern as occurred in the U.S. Top Ten (and others in general) brands. Cigarettes with less than 10 mg tar had an 11% market share in 1979, so

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

you can see the main thrust of the low tar market is still in the 10-14 mg range. The "Tar Market Trends" graph (B.-10) shows once again that all growth lies in the low tar realm. The number of full flavor cigarette brands has not increased since 1976, while the 10-14 mg range has more than doubled during that same time. The sub-10 mg cigarettes have shown a slow, but stady growth.

The United Kingdom has lagged behind the U.S. in their drive against full flavored cigarettes. Graph B.-11 shows the average tar delivery in 1965 was 31.4 mg, about where U.S. deliveries were in 1958. However, they have dropped rapidly in recent years, falling to half that value (15.8mg)by 1980. Nicotine levels have also plunged, from 2.08 mg in 1965 to 1.35 mg in 1975. Britain now has over 25 low tar brands, including a number of ultra low-tar brands.

In other European countries, the story is much the same. Low-tar cigarettes (under 10 mg tar) sales in France increased 500% from 1976 to 1981. They now hold an 8% market share. Ultra low-tar cigarettes, such as ROYALE ULTRA LEGERE (0.9 mg tar, .09 mg nicotine) are gaining customer acceptance. Germany has long been a forerunner in the low tar market. It is essentially a completely low tar market, by U.S. standards, with all cigarettes 16 mg tar or less. The brands are heavily

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

concentrated in two groups, one in the 11-13 mg range, another in the 6-8 mg range. About one quarter of sales fall into the U.S. defined (but not German defined) ultra low category, although the "No Tar Market" of 0-2 mg is now vacant. About 7 years ago, several brands in the 0-2 mg tar group were introduced. The nicotine was correspondingly low. NSM, or non-smoking material, was also incorporated in some blends at this time. All of these failed, showing Germany was not prepared to accept No Tar cigarettes or non-tobacco product substitution. Austria presents essentially the same market situation as Germany. Italian low tar cigarette sales rose 12% in 1981, but this still only represents a 15% market share. In Spain, low tar cigarettes only accounted for 2% of 1981 sales.

The Japanese are partial to charcoal filters. Although the government holds the opinion that the effects of smoking on health have not yet been determined, tar and nicotine tables are displayed at all tobacco outlets, and low tar cigarettes are popular. Tar levels dropped from an average of 17.6 mg to 15.9 mg between 1975 and 1980, while nicotine fell from 1.28 mg to 1.05 mg over the same period. Ultra low tar cigarettes have not yet made an impact on sales.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Although the Australian government has no official definition of low tar cigarettes, there is an unofficial low tar ceiling of 12 mg tar. About 40% of cigarette sales fall into this category. Brands are divided into tar group intervals of 4 mg for official labeling purposes. As in Germany the ultra low-tar market share (German type definition - under 4 mg) is negligible, at 0.3%.

As may be expected, these same areas of the world are the ones currently practicing ventilation on a number of their brands. The U.S. is generally still ahead of the rest in the conversion to ventilated products Marlboro, for example, is being ventilated in most of Western Europe and Australia, but not Eastern Europe or Japan. The trend towards ventilation is firmly established in the regions discussed here. It has proved to be infectious.

2. Government Action

Government pressure has usually been behind the big push to lower deliveries in the industralized countries. Germany, Austria, Sweden and England have been especially vocal in the government opposition to full flavor cigarettes. As is evidenced by the preceding "Trends" discussion, these countries are in the forefront offering low tar products. In 1965, the German cigarette industry voluntarily

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

put a 25 mg tar/1.5 mg nicotine ceiling on filter cigarettes. They have continued to stay ahead of the government by gradually decreasing those upper limits. In other countries, the government has seen fit to impose legal ceilings. In 1982, both Spain and Australia passed legislation limiting the maximum permissible tar and nicotine levels. These were fixed at 24 mg tar/1.8 mg nicotine by the former, and 18 mg tar/1.6 mg nicotine by the latter.

Anti-smoking government action has been strong in Great Britain. There is usually some type of controversial bill being debated, covering the typical areas of publishing delivery yields, warnings, limiting advertising, etc. The government did succeed in 1979 in passing a "tar surcharge" tax on all cigarettes yielding over 20 mg tar. Half the high tar brands promptly disappeared. A vocal debate on whether or not to publish carbon monoxide deliveries has occupied much of the legislators' time. In Italy, the Ministry of Health began an anti-smoking campaign during the summer of 1982, especially aimed at teenagers. These are examples to illustrate the political climate in these areas. The other countries have similar situations.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

b. Developing Countries

1. Delivery Trends

The market trends in the developing countries are quite distinct from the regions previously discussed. Whereas most of the impetus to lower cigarette deliveries has come from governments in the industrialized countries, any changes to that end in the rest of the world has usually been instigated by large multi-national parent companies based in one of the industrialized countries. There are various reasons for this.

First of all, government regulation of everyday life is much less common outside of the industrialized countries. They do not try and tell their populous how many eggs a week they should eat, or that they can't have synthetically sweetened soft drinks because they could get cancer if they drank a case a day for fifty years. Such basic government requirements as denaturing alcohol before allowing its use as a tobacco flavoring is often not required in developing countries.

Secondly, Corporate Brands such as the MARLBOROS, WINSTONS, and DUNHILLS are made all over the world, not just in their base markets. Due to local usage and import laws, it is virtually impossible to make these cigarettes identical to the original. However, every Corporate Product Committee strives to make them as close as possible. Accordingly, when

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

MARLBORO deliveries drop in the U.S., they tend to drop, at least in the long term, everywhere. Nobody wants to have a product out there that bears absolutely no resemblance to the home product.

A third cause is the "Good Neighbor" issue. A number of U.S. and European corporations have been accused of producing or exporting abroad products that are deemed unsafe, unpopular, or controversial in the country of origin, but whose use is unrestricted in the country of sale. Such items as baby food, pesticide, and high tar cigarettes readily come to mind. As a result, these multi-nationals have faced everything from home-front criticism to worldwide boycotts. In part to cover this criticism, these companies have often introduced abroad products comparable to the home brands. Low delivery cigarettes are an example. If they sell, fine; the mechanisms are in place to give the consumer what they want. If they don't sell, no one can say such and such a country is a high delivery market for lack of choice. A point that is often missed is that in many countries, especially the poorer ones, imported cigarettes are a true luxury. When the opportunity arises to purchase imported or local premium (corporate brands) cigarettes, it is understandable for local consumers to demand a full flavor cigarette. Simple business sense instructs one to produce a product demanded by the consumer, even if that may be contrary to trends in other countries.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

For whatever reason, the introduction of up-dated, lower delivery corporate brands into world-wide markets exposes those countries to new trends. When they do catch on, it is usually a fairly slow process. Over time, these changes may be incorporated into the local brands, or they may remain exclusively a part of a few International trademarks. These are the main factors governing deliveries in the developing countries, not the government.

In spite of the fact there is little or no government pressure nor consumer demand to decrease deliveries, many developing countries now offer low tar cigarettes. The first low tar cigarette was just launched in late 1982 in the Philippines, SEVEN STARS LIGHTS. This is a 14 mg tar/.7 mg nicotine cigarette. Venezuela produces YES and LIDER. Argentina offers a number of brands under 15 mg. tar, such as GALAXY, JOCKEY CLUB SUAVES, and VANGUARD. Panama has MERIT, the Canary Islands makes 10 mg. tar NOBEL and Costa Rica makes DERBY, BOND, and GALAXY, all under 12 mg. tar.

Perhaps the biggest battle for the low tar market segment is currently being contested in Brazil. Philip Morris pioneered the trend in 1976, with the introduction of GALAXY. It is still the leading seller in the field, despite fierce efforts by the giant Souza Cruz company to dislodge it. GALAXY has a full range of brand extensions, ranging from 6-11 mg. tar.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

ADVANCE and CENTURY make up the rest of the triumverate. Low tar sales jumped from 4.5% to 7% from 1980 to 1981. Predictions as high as 25% of the total market by 1986 are being made. Given the size of the Brazilian market, the stakes are very high. Most of the new brands, hence money, is being devoted to this market segment. The top selling brands are still positioned in the 15 mg range, although brands with 2 mg tar and .2 mg nicotine are available.

In keeping with the low tar technology, many countries also produce at least one ventilated brand. Singapore, Guatemala, Chile, et al. have entered the race. MARLBORO is ventilated in such unlikely countries as Cyprus and the Ivory Coast, illustrating the spreading appeal of this development. It is an example of our shrinking world.

2. Government Action

We have already elaborated on the theme that government pressure is not the primary force behind whatever low tar/ ventilated cigarette trends that exist in the various developing countries. Often, in such countries as Brazil and Argentina, the cigarette companies generate so much revenue for the government due to extremely high tax rates that they are reluctant to bite the hand that feeds it. The governments there tend to concern themselves more with ensuring local raw materials are used than setting cigarette delivery limits or regulating packaging disclosures. Market trends are allowed to evolve through private forces.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

This is not to say government influence can be discounted as a factor effecting a trend towards lower deliveries. The possibility that strong government opposition to smoking may suddenly surface is all too real. Pakistan was the scene of an exceptionally venomous government-sponsored anti-smoking campaign during 1981. What had been a low-key issue blossomed into an all-out blitz directed by the Ministry of Health. T.V. propaganda ranging from 10 seconds to half an hour show everything from a lit cigarette changing into burning currency to a dying man captioned by, "This could be you if you don't give up smoking". In 1982, the campaign was stepped up, banning smoking in libraries, hospitals, and schools. The reasoning behind this campaign is somewhat unclear. At 490 cigarettes per year per person consumption rate, Pakistan is already one of the lowest per capita consumers in the world. In spite of this, tobacco taxes still accounted for 32% of the total excise taxes collected on manufactured goods. No doubt as a partial reaction to this, cigarette sales growth slowed to 2% while the filtered cigarette market share increased from 30% in 1980 to 38% in 1981.

In neighboring India, the existing anti-smoking forces increased their vigour in 1982 by requiring health warnings on packs and limiting public smoking areas. The Ministry of Health is also leading this campaign. The Saudis have passed legislation

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

that is likely to affect a number of other Arab countries. Early in 1982 they banned the sale of all cigarettes over 15 mg. tar and 1 mg. nicotine. Other countries may follow suite, and manufacturers may voluntarily remove full flavor cigarettes from the region to avoid controversies over the origins of any possible contraband high tar cigarettes that find their way into Saudi Arabia.

In late 1982, the government of Malaysia has taken the unprecedented step of refusing to grant interest-free small business loans to anyone who smokes. Medical tests will be conducted for proof. Their logic is that anyone who can afford to smoke doesn't need a loan.

These four markets have been chosen to illustrate the widespread involvement governments world-wide have exercised over the smoking issue. Telling an Arab who has been identified with the strong, Turkish cigarettes he can no longer buy full flavored cigarettes is akin to telling a German he must drink lite beer. It just isn't done. However, it is being done, and if it can happen in Pakistan and Saudi Arabia, it can happen anywhere.

c. Summary

I'm sure a number of people are wondering why so much time in a ventilation seminar has been devoted to market trends. Low tar trends and ventilation are closely related subjects. This will be covered from a different angle in the next section. By describing what is happening around the world concerning smoking,

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you may better judge where your own country stands relative to others. What signs seem to preceed an outburst of anti-smoking government action? What is behind the introduction of ventilated products in countries where government intervention is only a remote possibility? When should I voluntarily reduce deliveries to avert outside pressure, and when would that be an unnecessary complication? I don't claim to have answered all these questions, but to have presented the issue and shown the importance of addressing these questions. Government tax policies have deliberately been glossed-over here because they are first and foremost a means of generating revenue, not a measure of pro, neutral, or anti-smoking sentiment. Argentina and Brazil again serve as good examples. High taxes cannot be equated with vehement government opposition to smoking. Anti-smoking hulabaloo is a wonderful smokescreen for politicians to hide behind when seeking to raise tobacco taxes. If this is not a good indicator of smoking trends, what is? Every effort should be made to find out. Anticipation is the key; assumption is a sin when information exists.

Before undertaking all of the problems associated with ventilation, you should be sure why you are doing it. What are your goals? Is it necessary? Prudent? Can it wait? Will it boost sales? You better know the market before jumping in with both feet. The more you can learn from the experience of other countries, the better base you will have for the foundation of your own decisions.

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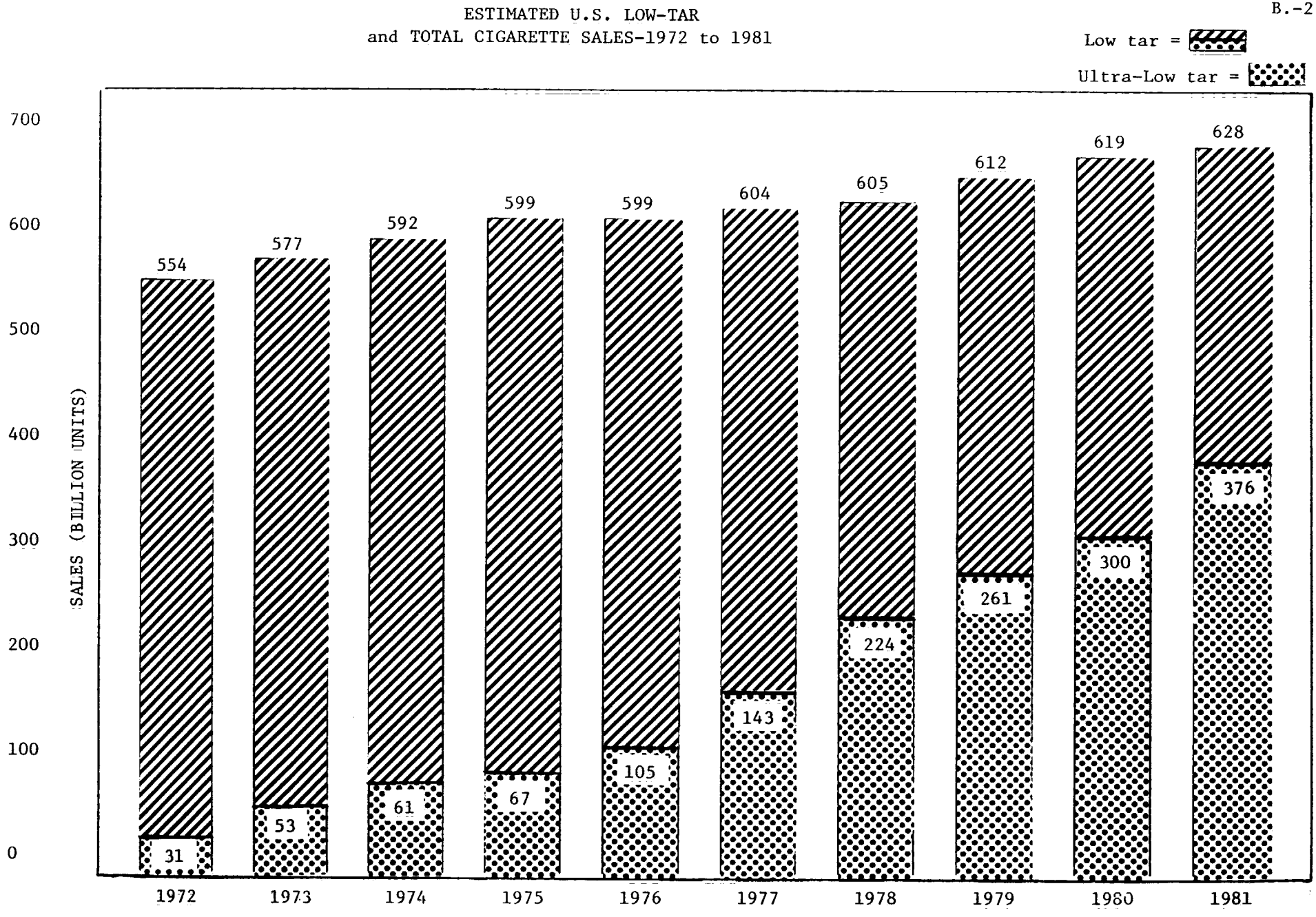
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

ESTIMATED U.S. LOW-TAR
and TOTAL CIGARETTE SALES-1972 to 1981



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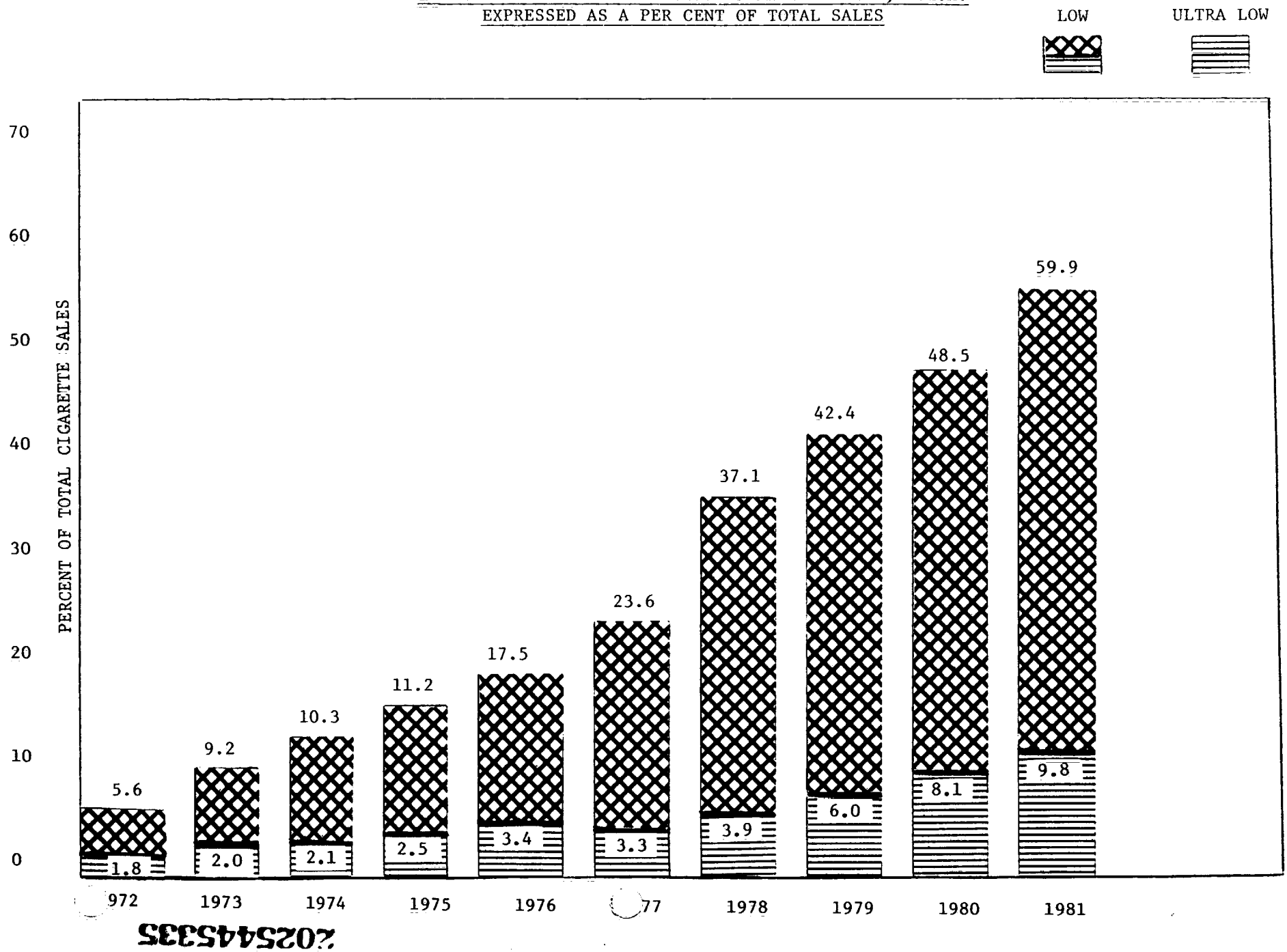
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

LOW AND ULTRA-LOW TAR CIGARETTE MARKET SHARE, U.S.A.
EXPRESSED AS A PER CENT OF TOTAL SALES



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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

YEAR	NUMBER OF NEW BRANDS INTRODUCED
1971	18
1972	5
1973	6
1974	24
1975	41
1976	12
TOTAL	106

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TOP 10 LEADING BRANDS

	1978	1979	1980	1981
1)	Marlboro Box & SP	Marlboro Box & SP	Marlboro Box & SP	Marlboro Box & SP
2)	Winston Box & SP	Winston Box & SP	Winston Box & SP * 3.	Winston Box & SP
3)	Kool Box & SP	Kool Box & SP	Kool Box & SP	Kool Box & SP
4)	Salem 85's	Salem 85's * 1.	Salem 85's *	Marlboro Lights 85's
5)	Winston 100's	Marlboro 100's * 2.	Marlboro Lights 85's *	Salem 85's
6)	Marlboro 100's	Winston 100's	Marlboro 100's	Marlboro 100's
7)	Salem 100's *	Winston Lights 85's *	Winston Lights 85's *	Winston Lights 85's
8)	* Vantage 85's *	Salem Lights 85's *	Salem Lights 85's *	Salem Lights 85's
9)	* Winston Lights 85's *	Vantage 85's *	Merit 85's *	Winston 100's
10)	B & H 100's *	Merit 85's	Winston 100's *	Merit 85's
	NUMBER LOW TAR BRANDS IN TOP 10 (≤ 15 mg)			
	2	4	5	7

1. Reduced to 15 mg in 1980
2. Box version introduced and included with SP
3. Reduced to 14 mg tar in June 1981

* Low-tar brand

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

CIGARETTE SALES FIGURES FOR TOP 10 BRANDS, 1978-1981 (in Billions)

FULL FLAVOR BRANDS

BRAND	Tar in mg. 1978	Tar in mg. 1981	1978	1979	1980	1981
Marlboro Box & SP	18	16	72.32	71.32	70.85	70.09
Winston SP & Box	20	1. 14	51.35	46.93	45.41	44.20
Winston 100's	20	1. 14	15.15	14.05	13.62	13.78
Salem 85's	17	2. 15	23.10	20.25	17.70	16.70
Kool 85's	17	16	39.20	36.13	33.86	31.92
Marlboro 100's	19	16	15.00	14.67	14.97	15.64
Benson & Hedges 100's	18	17	11.49	10.16	9.48	9.02
Salem 100's	19	16	12.65	11.57	10.69	10.59

LOW TAR BRANDS

Marlboro Lights SP & Box	12	11	9.31	11.44	15.47	19.23
Merit 85's	10	8	9.41	11.93	13.64	12.27
Vantage 85's	12	9	12.20	12.40	11.45	11.28
Winston Lights 85's	15	10	11.60	13.34	14.47	14.24
Salem Lights 85's	12	9	11.25	13.20	13.77	13.97

1. Lowered to 14 mg tar in 1981

2. Lowered to 15 mg tar in 1980

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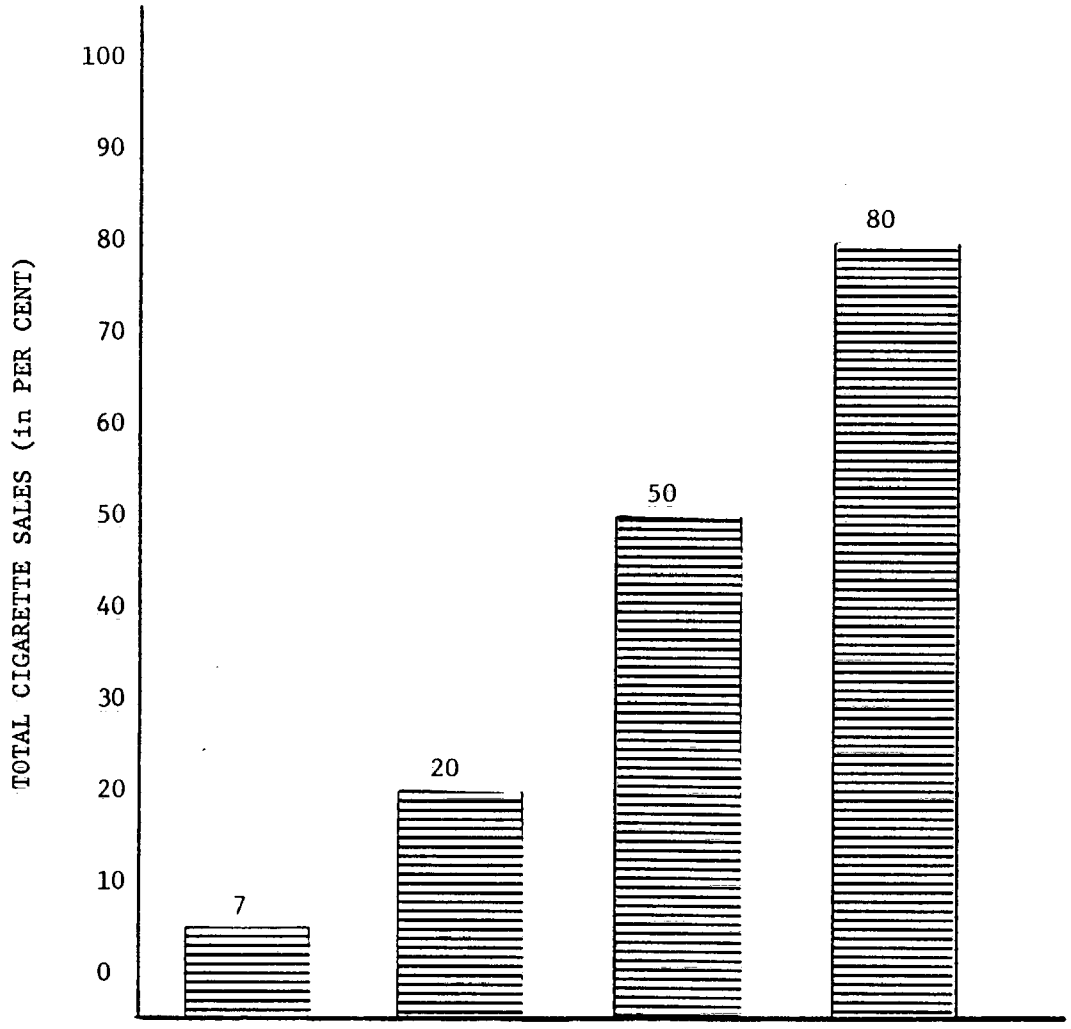
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

VENTILATED CIGARETTE BRANDS AS A PER CENT
of TOTAL U.S. CIGARETTE BRANDS



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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

PHILIP MORRIS VENTILATION BRAND HISTORY

	BRAND	DATE INTRODUCED	DATE VENTILATED	DILUTION LEVEL	DATE DILUTION LEVEL CHANGED
.)	Alpine 85 mm	9/59	9/71	12	
				26	1/72
				20	1/77
				15	10/77
				14	1/79
2)	Benson & Hedges 70 mm	4/55	3/76	27	
				78	6/77
3)	Benson & Hedges 85 mm	4/56	9/79	20	
)	Benson & Hedges 100 mm	8/66	4/79	8-15	
5)	Benson & Hedges Menthol 100 mm	8/66	4/79	8-15	
')	Benson & Hedges 100 mm Box	10/74	4/79	8-15	
7)	Benson & Hedges Menthol 100 mm Box	10/74	4/79	8-15	
)	Benson & Hedges Lights 100 mm	10/77	10/77	30	
9)	Benson & Hedges Lights Menthol 100 mm	10/77	10/77	30	
0)	Benson & Hedges Lights 100 mm Box	5/80	5/80	30	
.)	Benson & Hedges Lights Menthol 100 mm Box	5/80	5/80	30	
2)	Benson & Hedges Deluxe Ultra Lights 100 mm	7/82	7/82	50	
3)	Benson & Hedges Deluxe Ultra Lights Menthol 100 mm	7/82	7/82	50	
4)	Benson & Hedges Multifilter 84 mm	3/64	4/71	29	
5)	Cambridge 85 mm	4/80	4/80	78	
6)	Cambridge 83 mm Box	4/80	4/80	90	
7)	Cambridge 100 mm	4/80	4/80	57	

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

PHILIP MORRIS VENTILATION BRAND HISTORY

	BRAND	DATE INTRODUCED	DATE VENTILATED	DILUTION LEVEL	DATE DILUTION LEVEL CHANGED
5)	Galaxy 85 mm	1/65	12/79	14	
9)	Marlboro 80 mm Box	1954	4/79	8-15	
0)	Marlboro 85 mm	1958	4/79	8-15	
1)	Marlboro Menthol 85 mm	1/66	9/71	12	
				26	1/72
				20	1/77
				15	10/77
				14	1/79
2)	Marlboro Lights 85 mm	12/71	7/74	18	
				26	5/77
				21	10/77
				8-15	4/79
3)	Marlboro Lights 85 mm Box	8/80	8/80	8-15	
4)	Marlboro 100 mm	6/67	12/70	14	
				0	3/74
				8-15	1/79
5)	Marlboro 100 mm Box	6/67	12/70	14	
				0	3/74
				8-15	1/79
6)	Marlboro Lights 100 mm	1/78	1/78	23	
				8-15	1/79
7)	Merit 85 mm	12/75	12/75	25	
				30	3/76
				25	7/77
				29	1/78
				30	1/79
28)	Merit Menthol 85 mm	12/75	12/75	25	
				30	3/76
				25	7/77
				29	1/78
				30	1/79

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

PHILIP MORRIS VENTILATION BRAND HISTORY

	BRAND	DATE INTRODUCED	DATE VENTILATED	DILUTION LEVEL	DATE DILUTION LEVEL CHANGED
29)	Merit 100 mm	1/77	1/77	30	
30)	Merit Menthol 100 mm	1/77	1/77	30	
31)	Merit Ultra Lights 85 mm	2/81	2/81	53	
32)	Merit Ultra Lights Menthol 85 mm	2/81	2/81	55	
33)	Merit Ultra Lights 100 mm	10/81	10/81	53	
34)	Merit Ultra Lights Menthol 100 mm	10/81	10/81	55	
35)	Parliament 80 mm Box (After 4/79, changed to "Parliament Lights 80 mm")	5/69	10/76	30 25	1/77
35A)	Parliament Lights 80 mm Box	4/79		30	4/79
36)	Parliament 85 mm (After 4/79, changed to "Parliament Lights 85 mm)	5/69	10/76	30	
37)	Parliament 100 mm (After 4/79, changed to "Parliament Lights 100 mm")	11/67	10/76	30	
38)	Philip Morris International 100 mm Box	4/74	10/79	10	
39)	Philip Morris International Menthol 100 mm Box	4/74	10/79	9	
40)	Saratoga 120 mm	4/75	4/75	25	
41)	Saratoga Menthol 120 mm	4/75	4/75	25	
42)	Virginia Slims 100 mm	7/68	10/78	15	
43)	Virginia Slims Menthol 100 mm	7/68	10/78	15	
44)	Virgini Slims Lights 100 mm Box	8/79	8/79	38	
45)	Virginia Slims Lights Menthol 100 mm Box	8/79	8/79	38	

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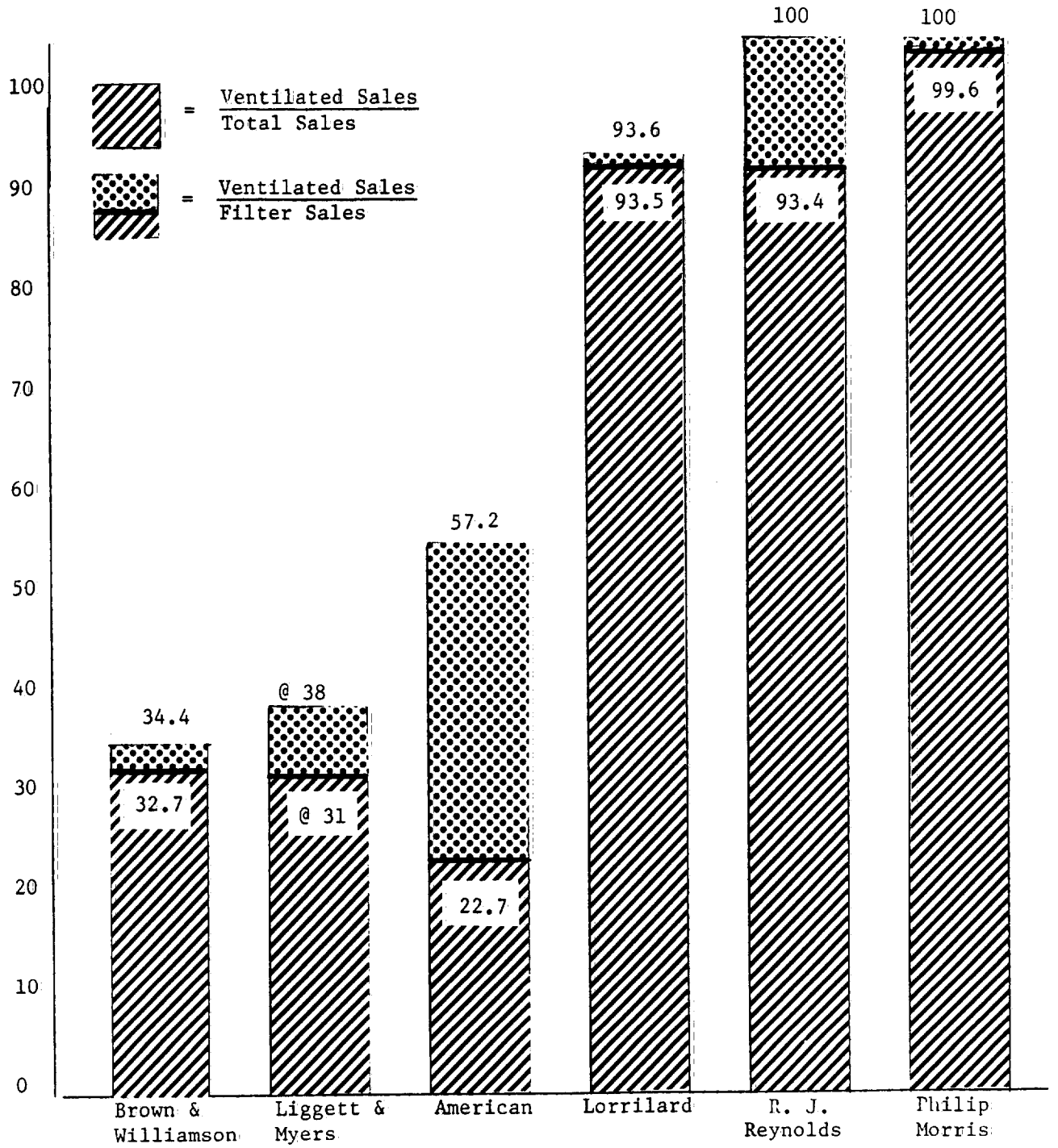
Source: https://www.industrydocuments.ucsf.edu/docs/qlnm0000

VENTILATED CIGARETTE SALES AS A PER CENT of FILTER SALES; and of TOTAL SALES BY COMPANY

Jan. - June 1982



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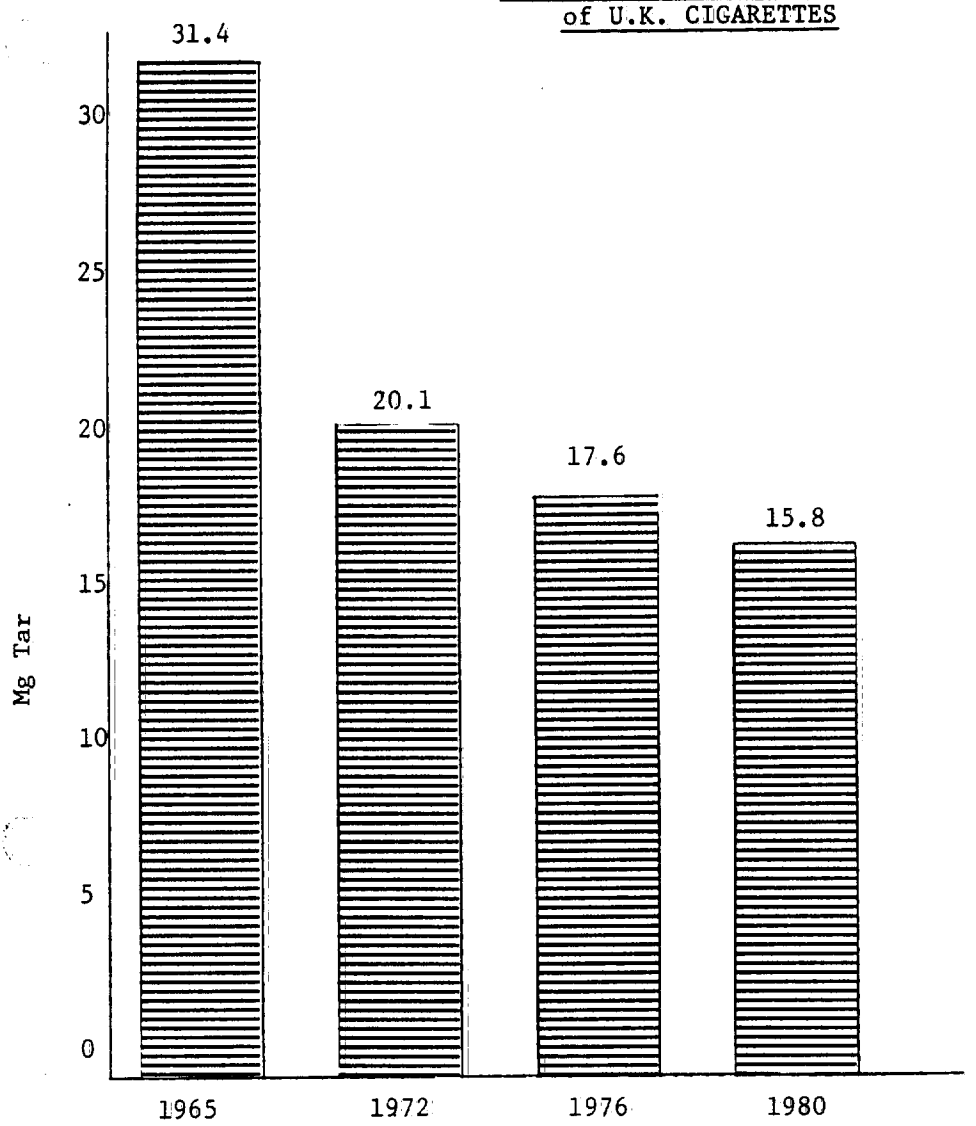
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

AVERAGE TAR (mg) DELIVERY
of U.K. CIGARETTES



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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

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C. ALTERNATIVES FOR ACHIEVING LOWER DELIVERIES

1. Introduction

Once the decision has been made to reduce cigarette deliveries, the next question is, "how should I do it". While there are dozens, possibly hundreds of ways to do this, there are only three main areas of consideration: modifications to the tobacco, the cigarette, or the filter. Each one has it own particular merits, drawbacks, and limitations. Perhaps the key word is limitations. An underlying assumption to any delivery modification is the cigarette must still be acceptable to the consumer. An extremely low DPF filter will drastically decrease deliveries. It can also make the smoker feel he will suck his lungs into his throat before he gets puff one of smoke. The variable must also be cost effective. If you want to decrease a full flavored cigarette brand by 2 mg, you may decide to begin laser perforation. However, if this is all you want to do, it would be crazy to spend upwards of a million dollars to buy a laser unit when a simple change in cigarette paper may be all you need to do.

Flexibility is important to retain when lowering deliveries. If you chose to modify deliveries only by buying low tar and nicotine leaf, then you are locked into that decision when the time comes to withdraw the leaf from the warehouse several years in the future. Plan B is always nice to have available. Controllability is crucial to any manufactured product. If you are in a restricted single supplier or limited supplier market, it would be foolish to rely on specific tipping or cigarette paper properties to achieve your targeted delivery decreases if that supplier gives you 30 second

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

paper one week and 50 second paper the next, all with the same code number.

By addressing each of these four points, acceptability, cost, flexibility, and controllability, you should be able to reach a feasible solution. The optimal solution is always the one you hope to achieve, but insufficient funds, time or a host of other problems may prevent the short term implementation of that course of action. Good planning can eliminate the controllable variables from limiting your choices. It is usually better from a taste stand-point to use several methods to lower tar deliveries than just one. For this reason, it is important to consider all the options.

The big problem with lowering deliveries has always been maintaining rich tobacco taste as tar and nicotine percentages are decreased. These components are instrumental in taste. Because of this situation, the main effort of most cigarette R & D departments has been the fight to seek alternative methods to replace diminished taste. Over 2000 components have been identified in smoke. Extracting or synthesizing some of the elements instrumental in full tobacco taste and mixing them back into after cut flavoring has been a major contributor in the increasing consumer acceptance of lower delivery cigarettes. Services such as this are one of the more important ones that large multinational corporations can offer small affiliates or licensees who are unable to spend large sums on R & D budgets.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

With these points in mind, we are ready to present the most important alternative means for lowering deliveries. There are many components in smoke delivery, tar, nicotine, and CO being the most commonly discussed. Utilizing various alternative combinations will yield greater flexibility in modifying not only levels, but relative ratios.

2. Tobacco Modifications

a. Genetic/Blend

Research has shown the chemical composition of tobacco to be receptive to genetic modification. It is also very changeable by processing, environment, fertilization, et. al. The following excerpts from Marian DeBardeleben's "Review Paper on Variables Influencing Tar/Nicotine Yields in Cigarette Smoke" will give you some idea as to the possibilities. It is the sheer number of these variables that will illustrate the difficulty in trying to achieve specific delivery goals. There is no reason, however, why available leaf technology cannot be used to modify chemical components, hence deliveries, in generalized terms. More accurate delivery targeting can then be continued through other means. Here, then, are some of the variables.

"Tobacco grown in a moist climate is generally lower in nicotine than that grown in a dry climate. Soils deficient in calcium or boron, or rich in nitrogen or chlorine, tend to increase nicotine level. High pH breaks down nicotine.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Topping, suckering, and wide spacing increase nicotine yields. Certain herbicides and nematocides decrease nicotine content.

Within the plant, tar and nicotine yields appear to increase from the lower stalk positions to the higher. On the leaf, more nicotine is found on the sides than in the middle. As the plant matures, the overall nicotine content increases. Curing decreases nicotine, air curing moreso than flue curing. Most phases of processing also decrease nicotine content. Casing with sugars and/or glycols reduce the overall transfer of nicotine to the smoke, but tend to increase tar deliveries."

These points only touch the surface of the subject. It is an involved science to study yield variables. Obviously, different types and grades of tobacco have different chemical compositions. Blending can be and is used to maintain a similar overall blend or series of blends from year to year. The early 1970's saw a period of mass buying of low nicotine tobaccos in order to decrease deliveries. Downstalk tobacco suddenly became more popular. However, the recent trend has been more towards buying good, full-bodied leaf, and then modifying the smoke. Less complicated flavor work is then needed to maintain a good smoke.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

In talking about tobacco types in a very general way, and on a mg/gram of component smoked basis, we can say Bright tobaccos deliver slightly more tar than Burley. They also deliver about 10-30% more nicotine. Oriental delivers almost as much tar as Burley, but about 40% less nicotine. Regarding gas phase deliveries, Burley delivers about 35% more CO than Bright and 50% more than Oriental. Burley also delivers 270% more NO than Bright and 350% more NO than Oriental. By varying the percentage of each type of tobacco in the blend, as well as varying the grades in the blend, the cigarette deliveries can be adjusted up or down. All of these figures will vary from year to year, blend to blend, and country to country.

There are, however, a number of drawbacks to using blend for these purposes. PM USA is committed to using one standard DBC blend for each type of tobacco, both for cost purposes and smoother production/inventory purposes. This philosophy extends into using only a minimum of brand blends. International locations are beginning to move in the same direction. If we adopt this philosophy, use of blend to modify deliveries will be very limited. Even if multiple blends are used, there is only so much that can be changed and still retain an American blend, or any other blend for that matter, before the whole blend concept breaks down. Subjective taste differences, yearly crop variations, and leaf availability all are limiting factors upon blend modification to alter deliveries. Chemical testing begins after the first leaf purchases, not before. It is therefore not desireable to overemphasize tobacco blend or genetics for delivery reductions.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

b. Modified Tobaccos

A second alternative means for changing cigarette deliveries is through so-called modified tobaccos. This includes reconstituted tobaccos, expanded tobaccos, and expanded or improved stems. All of these modified products are products of improved tobacco utilization programs. It is as a sideline that these products can be used as substitutes for leaf to alter deliveries. Even if substitutions are made entirely for economic reasons, you should be aware of the delivery modifications. Thus you will know if by substituting 5% RL in place of Bright on a ventilated cigarette, you will have to decrease ventilation by "X" per cent if you want tar deliveries to remain constant.

Before narrowing the discussion to modified products utilized by Philip Morris, U.S.A., let's take a look at an overview of the marketplace. It is important to keep in mind the variability of processes, blends, controls, etc. from place to place that can yield results quite different from other studies. That will become apparent after viewing the second set of figures specific to Philip Morris. Rather than demonstrating inaccuracies in testing or indicating the lack of value of such testing, it points out the difficulty of monitoring/controlling said variables. In such a case, frequent testing is all the more important. Once again, though, the problems of using modified tobaccos to achieve specific delivery reductions will become clear.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Table II shows the main reconstituted commerical sheet processes. Table III compares the relative chemical characteristics of them. The Philip Morris Process is the slurry-type RCB process, while the Schweitzer Process is essentially what we call RL. All sheet shows similar or reduced tar levels to the control tobacco blend. Nicotine levels are reduced from one quarter to one half. All sheets show higher NO levels, while CO is either equal or higher. Generally speaking, the paper process sheet reduces tobacco chemical components to a larger degree than the slurry, process sheet. In addition, foamed, or highly aerated sheets have been found to lower tar, nicotine, phenols and benzo (a) pyrene levels more than unfoamed sheet.

A quick look at expanded tobaccos compares the old PM ammonia expansion process with RJR puffed, a control blend, and the commercially unviable freeze-dried process. Table IX shows the smoke composition typical to each. Nicotine levels of all drop about 40%, while tar was about the same for PM and roughly 20% reduced by the other two processes.

The discussion will now focus on Philip Morris versions of the modified tobaccos, RL, RCB, ET, DIET, and ES. Table C.-1 is useful to illustrate the general delivery trends of the various blend components. The figures are for discussion only, as there are far too many variables to yield consistent data. These figures are on a gram for gram basis, so further caution is needed when looking at this table, because the modified components are not

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

substituted for leaf on a pound for pound basis, due to varying densities and CV's.

Table C.-2 makes the comparison a little easier, expressing the modified tobacco component deliveries as a percentage of the bright and burley deliveries. As you can see, the reconstituted products only deliver about one third the level of nicotine as the leaf products. The RCB tar levels are essentially equal, but RL deliveries are only half as much. Both types of sheet deliver substantially more CO, with NO levels approximating Burley levels.

ES has lost a good portion of its particulate matter during processing, so tar and nicotine levels will be substantially lowered by substituting ES for leaf. CO and NO deliveries are higher compared to Bright, but lower when paired against Burley.

The two expanded Bright components have very similar tar levels as leaf, but much less nicotine. CO levels are essentially higher, but NO levels are generally much less.

To get a more meaningful idea of the comparibility of the three expanded products, keep in mind that you need only about 60% as much ES and about 50% as much ET or DIET to make the same firmness cigarette as a 50/50 bright/burley blend cigarette. Therefore, you can see how substituting ET or DIET for leaf has become a very popular practice in low and ultra-low tar cigarettes.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

ET substitution has become particularly popular to lower CO deliveries. ES is useful for the same reason, but expanded tobacco can yield a much greater weight savings. The reconstituted products actually weigh more than leaf, so their delivery contribution will increase relative to leaf. However, RL will still decrease both tar and nicotine deliveries.

As useful as modified tobaccos are for reducing cigarette deliveries, they do have their limitations. The amount that deliveries can be reduced by these means is limited by negative subjective response that occurs once different maximum percentages of various modified components are exceeded in the blend. It would be too complicated to derive specific numbers here, as these tolerable maximums depend so much on the other components in the blend, the flavor/casing type and level, the target delivery level of the cigarette, etc. You can use more DIET than ET; you can increase RL if ES levels are lowered, and so on and so forth. Another obvious drawback is the capital expenditure necessary to manufacture modified products. Nonetheless, modified tobaccos are very useful when used in conjunction with ventilation to lower deliveries.

C. Cut Rag Width

There have been a number of studies done on cut rag width. Some of them have been contradictary, others inconclusive. Philip Morris studies have shown that total tar deliveries decrease as shred size increases, while nicotine remains constant

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

or increases slightly. Although per puff deliveries decrease, increased puff count tends to balance this phenomenom. These were on 10-60 cuts per inch samples. A.W. Spears came up with similar conclusions in his 1974 studies. He also found very fine cuts (0.42mm) to yield CO contents 25% higher than a course (1.27mm) cut shred. As the cut becomes very fine, filling power (CV) decreases, so more tobacco is needed to fill the rod. This increases tar deliveries, as would be expected.

Cut width is usually a variable that once chosen, remains constant. It affects too many other things ie. puff count, burn rate, CV's, etc., to be attractive for modifying deliveries. It is enough to know its effects when examining delivery interelationships.

3. Cigarette Modifications

a. Weight/Density

Employing tobacco weight reduction to reduce availables has been used, but this is probably the most limited method available. Weight reductions not accompanied by corresponding increased filling power, or CV, are unusual. This is because smokers are sensitive to the firmness of cigarettes. Both the feel and appearance of a cigarette suffer when firmness falls below a certain level. As a general guideline, Philip Morris tries to maintain a maximum cigarette compacimetric firmness number of 32 (mm x 10), preferably lower. It is nearly impossible to generalize about a minimum and weight, due to

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

varying amounts of expanded product in the blends. Tar and nicotine deliveries increase as weight and density increase up to about 1 gram, assuming circumference remains constant. For as yet uncertain reasons, both entities begin to decrease above this weight. Mosby and Lang theorized higher tobacco column filtration could account for this. The subject is still a grey area.

b. Length

Increasing the length of the cigarette (tobacco column) will, with all other variables held constant, increase the particulate phase of delivery, but decrease the CO content. Per puff delivery of tar and nicotine decreases, but the total increases due to higher puff count. There are several mechanisms at work that explain these trends. The added tobacco in the longer column acts as an extra filtration chamber. It also takes the smoke longer to reach the smoker, allowing more time for particulate matter to condense out. On the gaseous side, the larger surface area of the cigarette paper allows more air to enter (dilute) the smokestreams and various gas components of the smokestream to diffuse through the paper. A larger volume of "deadspace", or simply air void, is also created. This changes the relative make-up of the gas phase due to the different co-efficient of diffusion of each type of gas. Accordingly, it depends whether you are trying to reduce particulate matter or certain gases as to the decision to chose modifying cigarette lengths to affect deliveries.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

c. Circumference

Decreasing the cigarette circumference, with density constant and tobacco weight decreased, will increase the burn rate, increase air and smoke velocity and decrease puff count. There are conflicting factors at work. The lower amount of available tobacco and higher burn rate serve to decrease particulate and gas phase delivery. The faster velocity allows for less time to condense or diffuse. Less surface area means less filtration in the tobacco column. These two factors act to increase deliveries of most smoke components. Other unproven factors, such as altered oxygen usage and heat transfers, combine to cause the overall affect of decreased cigarette circumference to be a decrease in TPM and CO. This includes both nicotine and tar decreases. A decrease in circumference from 26 mm to 23 mm has been shown in one study to decrease tar levels from 23.3 mg to 18.2 mg, and nicotine from 1.56 mg to 1.21 mg. This is a 22% reduction in deliveries in both cases. The same decrease in circumference decreased CO levels only 11%, from 12.8 mg to 11.4 mg. You can see the CO/Tar ratio is altered when circumference changes. However, within the range of practical cigarette circumferences, the changes are not large in magnitude. You should keep in mind that the ratio is not linear.

d. Moisture

The moisture content of a cigarette does affect delivery levels. TPM, tar, and nicotine all react inversely with moisture. They all decrease as moisture increases. This is in spite of the fact higher moisture decreases burn rate and increases puff count. Pressure drop increases, probably causing a higher filtration level. While per puff levels of tar show significant decreases over a range of

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

moisture, the total tar change is negligible. A change from 5% to 20% moisture only decreased tar from 20.8 to 20.4 mg, or 2%. Moisture content has a much greater influence on nicotine. The same range in moisture changed nicotine from 1.38 to 1.00 mg. or a 38% decrease in nicotine for a 15% increase in moisture. Nicotine seems to decompose more rapidly when moisture levels increase. Sidestream nicotine content increases, unlike the mainstream content. This increase is still less than the decrease in mainstream nicotine, making a net total decrease in nicotine as moisture increases.

This information is important to know, but it is no secret that cigarette moisture targets are rather inflexible. They can wander only a few per cent before problems, such as storage difficulties arise. The possibilities of using moisture changes to alter deliveries are therefore very limited.

3. Cigarette Paper

Cigarette paper can be changed to modify deliveries in two basic ways. First, porosity can be varied. This alters burn rate, burn time, and diffusion levels. The second principle change in cigarette paper involves varying the level of burn additives to vary the burn rate and burn time. The additives are covered in detail in Section D., PAPER. As far as porosity is concerned, Graph C-3 shows the effect of cigarette paper porosity on puff count. A 100 CORESTA change in this range drops the puff count by about one complete puff. Graphs C-4 through C-6 show the effect of paper porosity changes upon tar, nicotine, and CO. These all assume a non-ventilated cigarette. None of these graphs are linear

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

like the puff count essentially is. Both tar and nicotine show a similar trend in being reduced much more by the initial increase in porosity than by the later opening up of the paper. From 50 CORESTA to 150 CORESTA, tar decreases about 2 mg and nicotine .10 mg. However, from 100 CORESTA to 200 CORESTA, the decrease is only 60% as great. Concerning CO levels, the opposite is true. They show a greater increase with increasing porosity. For the same ranges as above, the CO decreases about 3.8 mg for the first range, but 5.0 mg over the second range.

For practical cigarette purposes, at least as Philip Morris USA is concerned, we use no cigarette paper over 100 CORESTA, or 8 second Greiner, and we try not to go below 12 second Greiner, about 70 CORESTA. Therefore, the range which concerns us is about 25-70 CORESTA. Over this range, the tar, nicotine, and CO drop roughly 1.6 mg, .6 mg, and 1.4 mg, respectively. These are more realistic figures about the degree to which cigarette paper porosity can be changed to alter deliveries.

Graph C-7 sums up in one graph the relative effect in per cent reduction on each component. Again, over the 25-70 CORESTA range, tar drops about 10%, while nicotine and CO are reduced almost equally 7.9% and 7.7% respectively. The rapid increase in the rate of reduction in CO after that point, and the almost indentical trail-off in the decrease in the rate of reduction for tar and nicotine, can be clearly seen on this graph.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Over the same range of 25-70 CORESTA (8-20 second Greiner), a Philip Morris study on Ecusta paper showed tar decreased 13% and nicotine 8%. This is a slightly higher tar reduction, but virtually the same nicotine reduction. However, when viewed over the 12-70 CORESTA (8-43 second Greiner), Celanese shows 14.5% and 11.3% reductions, versus 32% and 27% reductions recorded by Philip Morris. Data reported by Ecusta falls between the two, closer to Philip Morris than Celanese. What I am trying to caution against here is over-reliance on such graphs to exactly predict the cause and effect results than can be expected from such modifications. This is really true for the majority of these alternatives. You should use them as guidelines to get an idea of the range of values that can be expected.

The cigarette paper is a component that can be readily changed within a certain range, to modify cigarette smoke deliveries. It is commonly used to complement low tar cigarette design along with some of the other methods. The limitations on this are espoused upon in Section D., PAPER, and the effects of ventilation on the trends discussed above are detailed in Section I., CIGARETTE DESIGN. In a nutshell, porosity cannot practically be increased beyond 8 second Greiner or 100CORESTA due to a lack of opacity beyond that point. Machinability suffers, and cost is much higher.

4. Filter Modifications

a. Tow

When looking for a way to reduce deliveries, the first impulse is to look to the filter. From the time cigarette filters of

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

crepe paper were first introduced in the 1920's to the much improved cellulose acetate filter of the 1960's, filter modification was practically the only method of consequence used to reduce deliveries. Cellulose acetate, commonly known as tow, was cheap, effective, simple, and easily machinable. These factors combined to create a rapid success story. The marriage with tobacco is still going strong almost thirty years after it was introduced. Cellulose acetate is effective in selectively removing smoke components soluble in that material and having boiling points between 100°C and 300°C. For example, 70-80% of phenols and 30-50% of particulate matter are usually removed by conventional filters. Cellulose acetate also selectively removes cresols at roughly at 75% SRE.

1. Cross-Section

   Tow fibers generally come in I, Y, X or O cross-sections, with the two former ones being the most frequently used. The effective area of the fiber is indicated by a circle circumscribed around the fiber shape. The "Y", followed by the "I" cross-section, have been found to give slightly higher removal efficiencies at constant total deniers. These changes are too small for all but very minor modifications.

2. Fiber Denier

   Lower DPF, or smaller diameter filter fibers, can increase the efficiency of particle removal during filtration to a small degree. Both Eastman and Celanese produce these ultra low DPF products. They help lower tar yields at a lower pressure drop than is possible using conventional tows. They are also more

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expensive and less firm, but do offer yield improvements. Figure (8) shows a comparison of 2 DPF and 5 DPF 24.8 mm circumference, 20 mm length filter particulate removals. You can see removals for tar, nicotine, and overall SRE are higher for the 2 DPF filter.. This is because more and smaller fibers are packed into the same space.

b. Dimension

A longer filter acts to decrease yields in a number of ways. It will obviously improve filtration efficiency, both by decreasing the amount of tobacco available for combustion and by adding more filter fibers. This combination causes one of the sharpest of the TPM decreases of all the alternatives. Experiments by Hartung and Stewart have shown a 10% decrease in butt (filter) length to increase TPM 24%. Figure 9 shows the improvement in SRE as filter length goes from 15mm to 30mm. A longer filter slows smoke velocity due to the higher pressure drop of the filter than the tobacco column.

The use of longer filters is obviously limited by both consumer acceptance of long filters, and by pressure drop. Once conventional filters begin to exceed 60% removal efficiency, the pressure drop becomes unacceptable. Generally speaking, at a standard air flow of 17.5 ml/sec, cigarette RTD cannot exceed 140 mm, or 5.5 inches of water and expect to receive consumer acceptance. Philip Morris tries to keep total cigarette RTD (unencapsulated) under 5 inches. This translates into a lower limit of roughly 13 mg tar using a conventional filter system. Below that point, alternate methods must be employed to decrease deliveries.

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An increase in filter circumference will decrease smoke velocity. This in turn will increase filtration efficiency. Particulate matter has more time to condense and diffuse.

c. Charcoal

Although relatively ineffective for the filtration of particulate matter, activated charcoal has been found to selectively remove condensible vapors with boiling points between 0 and 100°C. The level of activity refers to the depth of the pockets in the carbon particles. These directly affect its filtration efficiency. The carbon is selective for the gas phase because the pore size is not large enough for the effective removal of particulate matter. Carbon is classified as an adsorbent, which depend on a large surface area to use this filtration principle. Adsorption works by physically plating smoke vapors onto an extensive but relatively impermeable substrate. The carbon can be coated with metallic oxides to increase the selectivity for acidic gases. As an example of selectivity for a typical volatile smoke irritant, acrolein, Figure 5 shows a selectivity index for filters using successively more and more charcoal. Activated charcoal is also useful for selectively removing such other irritants as hydrogen cyanide, formaldyde, and acetaldehyde. SRE's from 60-95% can be achieved with these components.

In spite of its potential for modifying the gas phase, activated charcoal filters have not received widespread consumer acceptance. Obviously, any time volatiles or semi-volatiles are removed from

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the smoke stream, the taste changes, even if it is not actually noticeable. Some people claim they can detect a charcoal taste. Charcoal filters are often marketed with low or non-activated carbon, which defeats its purpose of delivery modification, but gives the Marketing Department another advertising angle. At any rate, there are essentially only two charcoal filter markets in the world, Venezuela and Japan. Many other countries manufacture them, but they are a minor product line. If your country should start to point the finger at any of the components adsorbed by carbon, it may be worth your while to look into using charcoal as a selective modifier. However, water rapidly de-activates the charcoal, so that by the time the cigarette is half smoked, the carbon has lost most of its filtration capacity. These factors have limited charcoals' appeal as a filtration agent. Charcoal can improve the taste of poor quality tobacco, but it helps very little as far as tar and nicotine removal are concerned.

d. Gimmicks

The cellulose acetate standard bloom filter is the workhorse of the industry, but many other alternatives have been proposed. Some of these are variations on the same idea, re-routing the fibers into channels, walls, folded corrugations, etc. The filtration properties are generally similar. The fancy looking results of all the re-engineering is usually done more for advertising purposes than any practical reason. They are "gimmicks" looking for a way to differentiate their product. This is not to say they are deceptive or inefficient. Some do increase the efficiency of the filter by increasing the travel length of the

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smoke in the filter. Filtrona, for example, has recently patented a filter that is supposed to have an improved tar/CO ratio. It seals off the center portion of the filter with polypropylene, or some other impermeable member, and re-routes the smoke to the periphery of the filter. Most unconventional filters are difficult, thus expensive to machine. Sticky substances have been inserted into filters, much like charcoal. The majority of unconventional filters have a problem with high pressure drop.

It would be narrow-minded to discount this group of filter types as unworthy of investigation. Some of them that have been nothing but gimmicks in the past are now getting more widespread attention. One such example is a polypropylene fiber filter. It is not wise for smaller operations who have no supplier problems to get heavily involved in experimentation with unconventional filter types or designs, as it can be a costly endeavor. So far standard cellulose acetate construction is still number one. Finding a substitute material or construction that is cost effective, machinable, and efficient has not been easy.

e. Additives

The addition of certain chemicals to the filter medium has been explored. Most prominent of these have been the plasticizers, which for example, can improve the selective removal of phenols from 70% to around 90%. However, the purpose of plasticizer application was and is to set the filter plug. It is not desireable to vary the plasticizer content with the aim of

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manipulating deliveries. There are far better ways to do it.

Although experiments have been made to find chemical additives that can be used to modify deliveries, it is rare to find an acceptable substance. It must meet a number of criterion, including low cost, machinability, tasteless, odorless, non-controversial, and effective. In the late 1960's, ammonium sulfamate was bandied about as a cigarette paper additive that could reduce deliveries. It was more a media darling than anything practically effective. Another one that has received some attention is glycerol. It has been found to reduce nicotine deliveries to the order of 12% when applied at a 5% rate on the filter. However, no one as yet is doing anything more than small scale tests. There are other variables to consider, but glycerol addition is a very workable alternative for selectively reducing nicotine levels.

Cigarette manufacturers have long been utilizing cigarette papers with burn accelerant chemicals added to the paper. The main purpose is of course to keep the cigarette burning between puffs, to avoid the burn-out problems associated with pipe smoking. An indirect result is a faster burn rate and burn time, yielding lower deliveries because of these changes. This is becoming a more important effect all the time. Citrates and phosphates are the main burn-accelerant additives, but there are a number of other metal alkalis that can be used. Burn retardants can also be applied to the papers. Occasional adverse publicity about fires that have been started by dropped cigarettes that continued to burn may contribute to a preference to minimize the use of burn accelerants and

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utilize paper porosity to modify burn rate as much as possible. However, the trend has reversed in some cases, and paper additives are now being considered by some as a better way to vary burn rate than is porosity. More will be discussed on this subject in Section D., PAPER.

f. Ventilation

The final major alternative for reducing deliveries is ventilation. There are many ways to ventilate the filter. These will be covered in detail in Section G. The cigarette itself can be ventilated through the cigarette paper, but very few cigarettes use anything but filter ventilation. As you will see, the method used for filter ventilation does not influence the final dilution level. Therefore, you can chose the one best suited for your needs. It should be noted that many of the ventilation methods have a specific, limited dilution range.

There are a number of advantages offered by ventilation that have caused virtually every U.S. manufacturer and many foreign cigarette producers to adopt ventilation into everyday use for lowering deliveries. Only ventilation offers practically a complete range of delivery modifications. There are U.S. ventilated cigarettes whose dilution level range from 6 - 97%. The former level will barely effect delivery levels, while 97% dilution will all but eliminate the tar and nicotine from the smokestream. No other alternative discussed here or anywhere else can offer this type of flexibility. In addition, the effects of ventilation can be readily predicted through models and formulas. This will be

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detailed in Section E. Ventilation can also be used in a limited way to selectively reduce some smoke components. It is currently the only acceptable way to remove CO and other basically non-reactive gases. These interrelationships will be discussed in Section F. Ventilation improves the efficiency of the filter by reducing the smoke velocity. It will also increase puff count, which may or may not be construed as an advantage. While ventilation can create some production headaches, it is still a more easily controlled variable than many of the other alternatives.

Cigarette ventilation does have its disadvantages. A ventilated cigarette is somewhat harder to light and keep lit when compared to a non-ventilated one. When certain types of ventilation methods are used, visible holes in the filter are produced. This can now be completely avoided if desired by chosing a different ventilation method. Some ventilation methods also produce filter tip stain patterns, a point to be considered should this be a problem. Although ventilated cigarettes reduce the impact or taste of the cigarette, most of the alternatives mentioned for reducing deliveries will also diminish taste. Only physical changes, such as weight, rod length, etc., will reduce deliveries without a loss of impact. Obviously, the scope of physical changes is very limited for reducing deliveries. Producing a ventilated cigarette will cause more machinability problems, if for no other reason than it adds one more parameter to be controlled. It will also increase production costs due to the extra step. A whole new area of technology has developed to deal with ventilation, so that most of the problems associated with it can be readily corrected. One of the biggest problems is to oversimplify the process. Ventilating effects a

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number of other variables, and in turn is affected by still others. In spite of any drawbacks it may have, it appears ventilation is here to stay.

5. Conclusion

All of the principle alternatives for lowering cigarette deliveries have been briefly covered in this section. They have been presented to illustrate the choices available, the interelationships, and the possible combinations. Ventilation is rarely used by itself, except at very low (15% ≥) dilution levels. Therefore, in order to avoid the trap of over-simplification, it is important to be made aware of the overall picture. Why import expensive ventilation machinery to lower tar deliveries 1 mg if you can afford to take a slight tobacco weight decrease and change cigarette paper porosity to accomplish the same end? You cannot properly analyze the big four criterion for chosing a means to lower deliveries - 1) Acceptability

2) Cost

3) Flexibility

4) Controllability

unless you know what the alternatives are. The cost may be acceptable, but is it the most cost effective choice? Can more flexibility be retained through another method at a similar cost?

Multiple methods to lower deliveries are usually best. That allows you to operate in the mid-range of the alternatives, rather than at their limits. Controllability always becomes a problem when operating at the limit of a process. Multiple methods allow more flexibility to be retained. Acceptability from a consumer standpoint is generally

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better when multiple methods are used to lower deliveries. Taste, pressure drop, and appearance are all easier to maintain this way.

In conclusion, if and when you chose to ventilate all or part of your cigarette production, make sure you have examined the alternatives. Know why you want to ventilate. Know what to expect. It will save a lot of headaches later.

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* TYPICAL AVAILABLES OF BLEND COMPONENTS (mg/g. component smoked)

	TAR	NICOTINE	CO	NO
BRIGHT	27	2.49	20	.17
BURLEY	25	1.94	27	.63
RL	14	.74	34	.64
RCB	27	.74	34	.58
ES	10	.42	23	.24
ET	30	.91	29	.17
DIET	24	1.58	23	.14

* For discussion use only. Figures not accurate for actual calculations.

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* TYPICAL MODIFIED TOBACCO COMPONENT DELIVERIES EXPRESSED AS A PERCENTAGE OF BRIGHT AND BURLEY DELIVERIES

USING BRIGHT DELIVERIES AS THE BASE - IN %

	TAR	NICOTINE	CO	NO
RL	52	30	170	376
RCB	100	30	170	341
ES	37	17	115	141
ET	111	37	145	100
DIET	89	64	115	82

USING BURLEY DELIVERIES AS THE BASE - IN %

	TAR	NICOTINE	CO	NO
RL	56	38	126	102
RCB	108	38	126	92
ES	40	22	85	38
ET	120	47	107	27
DIET	96	81	85	22

* For discussion purposes only. Figures not accurate for actual calculations.

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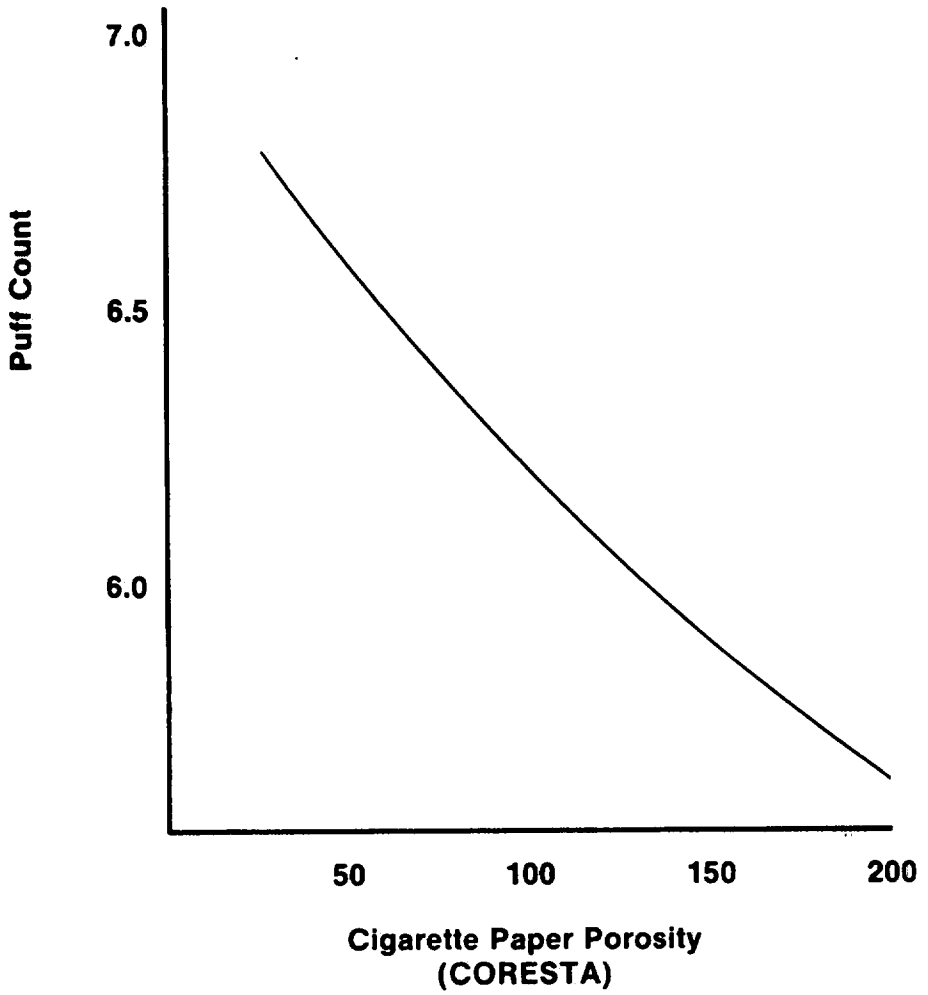
EFFECT OF CIGARETTE PAPER POROSITY ON PUFF COUNT

(0% Tip Ventilation)



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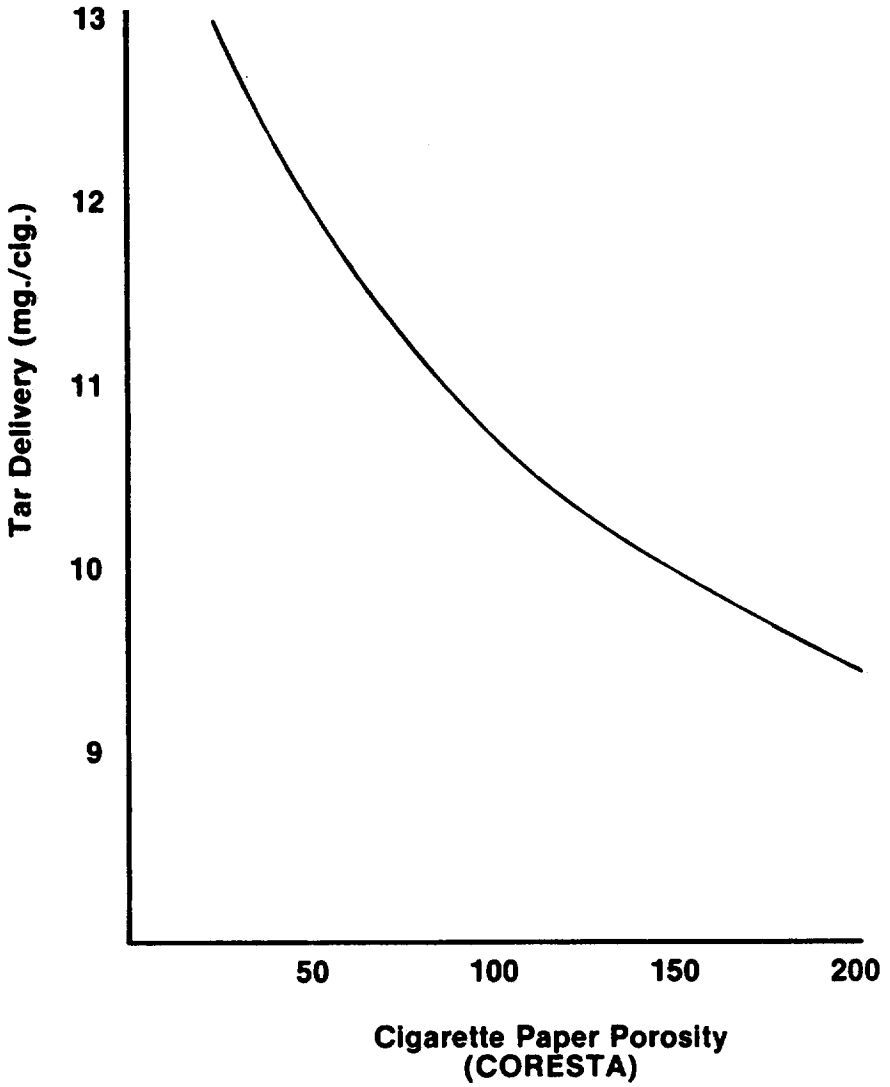
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TAR DELIVERY REDUCTION WITH INCREASING CIGARETTE PAPER POROSITY (0% Tip Ventilation)



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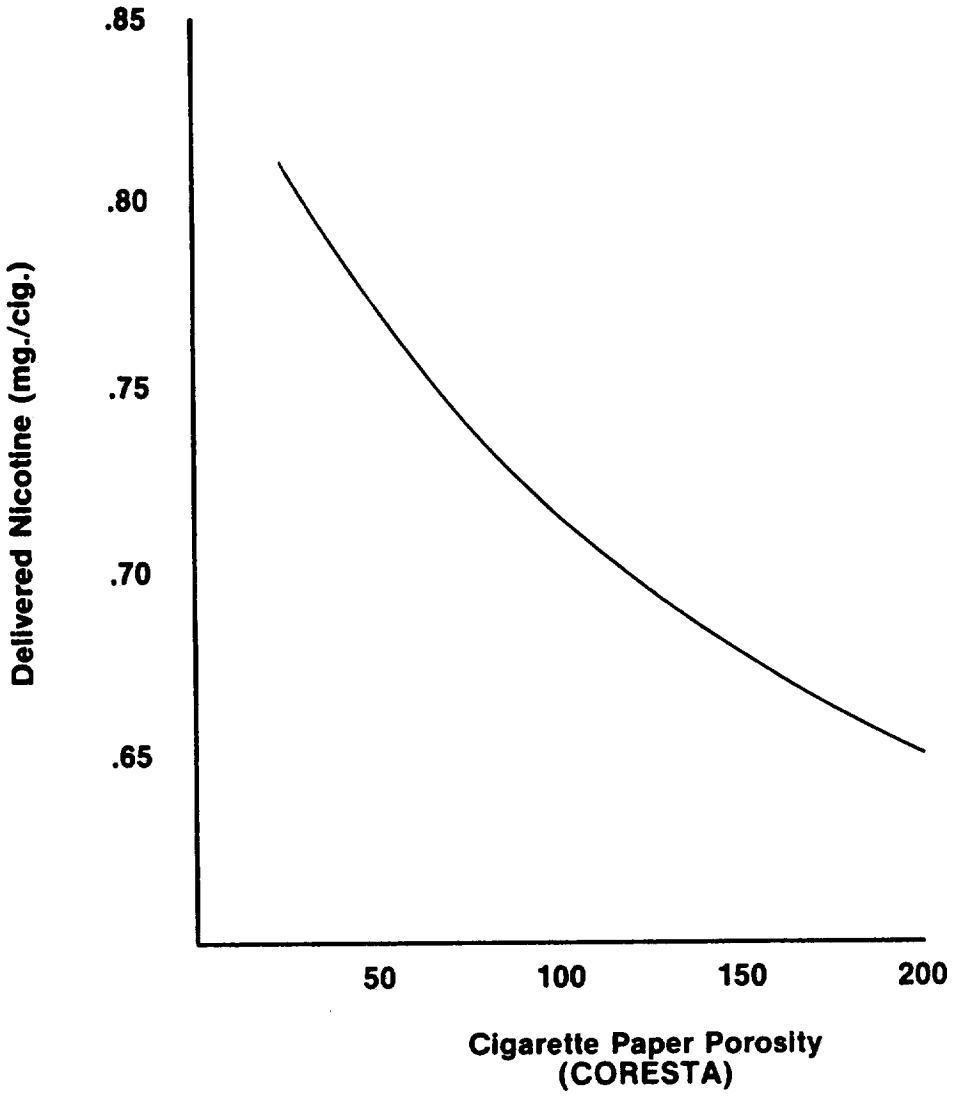
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

NICOTINE DELIVERY REDUCTION WITH INCREASING CIGARETTE PAPER POROSITY (0% Tip Ventilation)



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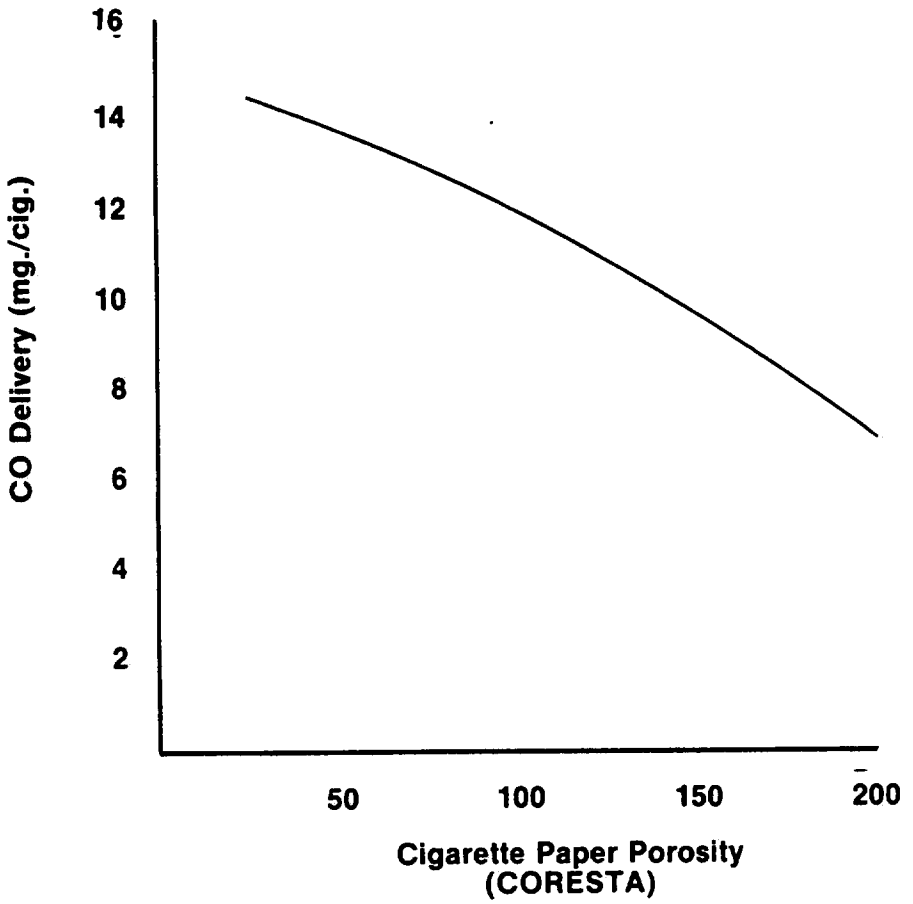
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

CO DELIVERY REDUCTION WITH INCREASING CIGARETTE PAPER POROSITY

(0% Tip Ventilation)



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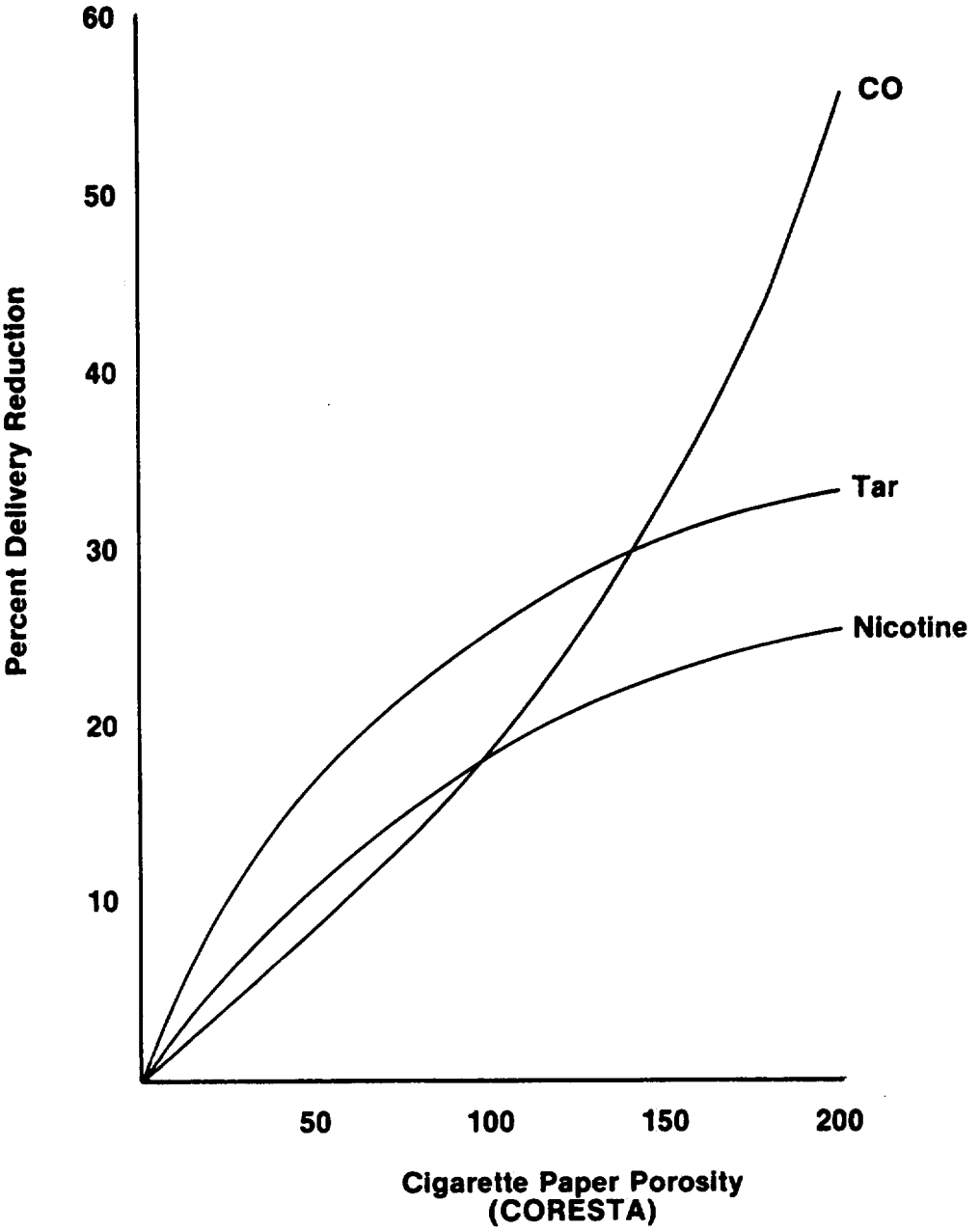
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

DELIVERY REDUCTION WITH INCREASING CIGARETTE PAPER POROSITY (0% Tip Ventilation)



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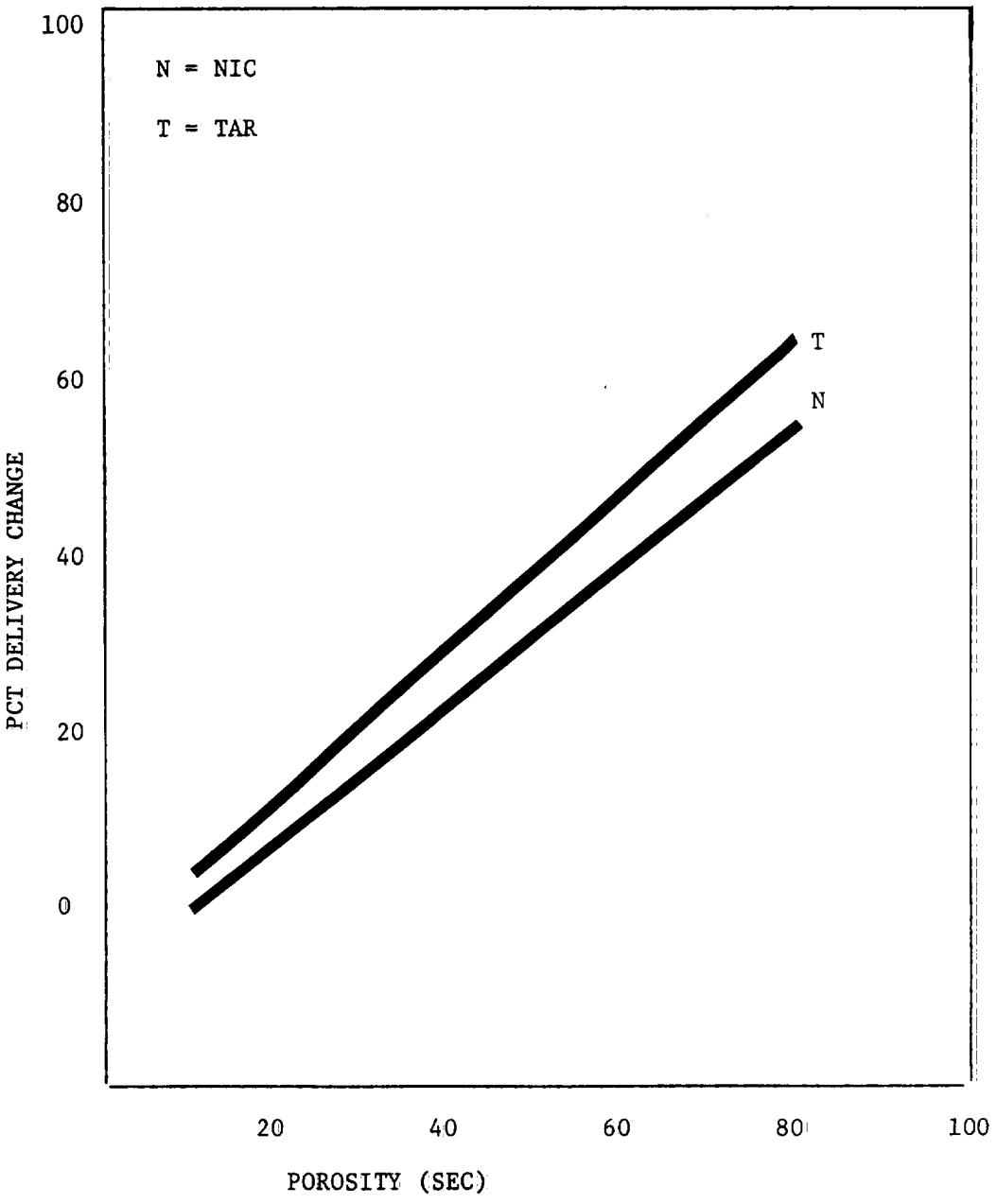
PHILIP MORRIS POROSITY TEST - ECUSTA PAPER



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D. Paper

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D. PAPER

Each of the three types of paper used in cigarette manufacture, the cigarette paper, tipping paper, and plug wrap, play an important role in ventilation technology. Whether it is a direct or indirect role depends upon the method used to ventilate. Whatever the role, a basic knowledge of the general properties of these papers is relevant to understanding the ways these papers can be manipulated to effect ventilation. They can allow, complement, or cause dilution. You will be better prepared to discuss your needs with your vendors when you can speak to them with some of their own terminology.

1. Cigarette Paper

With the advent of low tar cigarettes, cigarette paper structure is receiving more and more attention. Though it is rarely used by itself as a means of ventilation, it is usually a complementary part of the conversion. What is it that makes cigarette paper a specialty product? It must be a strong tissue paper of close, uniform texture. All cigarette papers are essentially interwoven cellulose fibers with filler particles. There is generally no sizing in the paper, although non-filter brands may use some resin size to minimize saliva bleed-through. The combustibility of the paper must be such that it neither glows more rapidly than the tobacco, nor hinders the tobacco in its burning process. The former can cause coal drop-off, as well as alter the flavor as it carbonizes. The latter may leave behind a charred, hollow tube as the tobacco outburns the paper. A combustible, or free-burning paper, has between 15% - 30% calcium carbonate filler. Domestically, Philip Morris uses only calcium carbonate as filler, in the 20-30% range. The ash that remains from the burnt cigarette paper should be a clean, fine white ash. The opacity must be at least 73% TAPPI for Philip Morris,

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preferably higher. This is an aesthetic quality that keeps the consumer from seeing the tobacco through the paper. Finally, the cigarette paper must be neutral on the taste buds, that is, it must not negatively affect the flavor of the cigarette.

Between 70% to 80% of the paper is fiber. The filler content is used to vary the porosity. Philip Morris U.S.A. stipulates that its cigarette paper must use 100% flax fibers. As some of you may already know, a number of suppliers have failed to qualify their papers due to the presence of hemp, esparto gross, wood pulp, or other fibers. These fibers can be the bast or bast/shive fibers. The other basic requirements for a good cigarette paper are a tensile strength of at least 2.3 kg/3 cm, and a basis weight of 23 to 27 g/m^2. Thickness usually ranges from .35 to .5 mm. Figure D.-1 shows typical parameters for papers currently in use at Philip Morris.

The two main variables of cigarette paper that are closely controlled to achieve the desired results are porosity and additive level. These two factors can be manipulated to alter the burn rate and burn time. The various smoke delivery components are largely a function of these two factors.

The porosity can be measured in several different units. The most commonly used are CORESTA, Griener, Sheffield and Borgwaldt. Figure D.-2 is a table comparing these scales. Philip Morris currently uses Greiner, while CORESTA is more widely accepted. This table must not be used as a direct conversion chart. Due to the differences in the measuring methodology, you may get variations from one machine to the

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next. Until one standard system can be utilized, charts like this will be a necessary evil. To repeat, it is only a general guide. Philip Morris will probably convert to CORESTA over time. The porosity, or permeability of the paper, is basically a function of the void volume in the paper, both its quantity and make-up. The fiber distribution, as well as the filler content, determine the permeability. By reducing the basis weight or density and manipulating the filler content, the sheet can be opened up or closed in. Opening the sheet will allow more oxygen to enter the paper, while facilitating the diffusion out of some permanent gases, such as CO. The increased burn rate will tend to counter-act some of the additional diffusion. Tar and nicotine deliveries also decrease with the increased porosity of cigarette paper. There are obviously limits to the amount of natural permeability that can be used. Cigarette paper that is over about 105 CORESTA (under 8 second Greiner) becomes unacceptable in its appearance. Its opacity is not sufficient.

The use of cigarette paper additives is prevalent both as a burn accelerant and as an ash conditioner. Philip Morris uses only citrates as (sodium and potassium acetate salts) a chemical additive. Some firms use phosphates. Philip Morris' experience has been that phosphates are useful mainly as an ash conditioner that does not promote, or increase, the burn rate. In addition, an off-taste has sometimes been associated with phosphates. Philip Morris normally uses papers with a 0.5 to 0.8% citrate level, although levels up to 2.5% are currently in use. Beyond 3%, citrate additives tend to deteriorate the paper and cause breakages. The high citrate paper can be used in place of or in conjunction with highly porous cigarette paper (ie 8 second Greiner) used for ultra-low

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tar brands. R. J. Reynolds and Lorillard have actually standarized on a 16 second Greiner porosity paper for most of their brands and varied the citrate level instead of the porosity to manipulate burn rates (hence deliveries). This alternative presents some advantages. Highly porous cigarette paper is significantly more expensive, less satisfactory in appearance, and more difficult to run (less tensile strength) than less porous papers. Nevertheless, the experience at Philip Morris has been that the changes in delivery from varying citrate level are not sufficient to justify using only one porosity paper. You retain greater range and flexibility by varying porosity levels.

A recent study by Celanese Fibers on citrate level has shown a linear decrease in puff count as citrate level increases. Although gas phase and particulate per puff deliveries increase with higher citrate levels, the lower puff counts can reduce the total yields of particulate deliveries. (Figures D.-3 and D.-4) Conflicting research exists on the effect of citrate level on CO delivery. Generally speaking, though, gas phase deliveries increase in total yield. Philip Morris has shown a 1 mg decrease in CO levels for zero citrate paper versus normal 1% citrate papers. Research by Schweitzer, FTR, and Celanese backs this up, but Ecusta does not. Zero citrate papers, though, produce a wide discolored band at the char line and a flakey ash. Schweitzer and Celanese have both shown that a maximum is forced on the curve between CO per puff increasing and puff count decreasing, as the citrate level increases. At high citrate levels, CO/cigt. can actually fall below that of untreated paper, a phenomenom shown by the Celanese graph D.-5. As dilution increases, the effects of citrate level on all deliveries becomes less and less. At 60% dilution for example, Philip Morris data shows almost no

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change in tar or nicotine deliveries as citrates are increased. Schweitzer and Celanese data substantiate this. In summary, permeability, rather than additive level, yields greater flexibility for delivery manipulation, especially as your product line becomes more highly ventilated.

2. Tipping Paper

The paper structure of tipping paper is different from cigarette paper. It is 65-90% fibers, usually wood pulp, and 10-35% filler. Cork paper has lower filler levels than white tipping papers. The percentage of the different fillers varies. Calcium carbonate is added for opacity and whiteness. Titanium dioxide is added in much smaller quantities for largely the same reasons. However, it has a much higher refractive index and is more uniform in particle size. This produces a whiteness and degree of opacity unattainable with only calcium carbonate filler. Clays, such as kaolin, impart opacity to non-white sheets. Iron oxide is used as a pigment for cork sheet. Organic dyes are used in the cork basesheet in place of higher iron oxide levels. They originally caused a bleed-out problem, but this has largely been resolved.

The cork inks have a pigment content (inorganic components) of anywhere from 25-75%. The range for the vehicle (organic components) is the same.

Tipping paper is significantly more substantial than the tissue paper used for cigarette paper. It is consequently heavier, more opacque, and brighter. It must still refrain from affecting the taste of the cigarette. Typical tipping papers used by P.M. U.S.A. have a basis weight of 31-41 g/m^2, and opacity and brightness percentage of 89 or higher. Insufficient

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opacity will make the tipping overlap too visible. Normal porosities range from 4 - 20 ml/15 seconds, although paper is readily available in double the porosity. Ultraporous tipping paper will be covered in Section G., TYPES OF VENTILATION. As the tipping paper is not consumed (burned), the components in it are not as strictly specified as cigarette paper. (ie. there is no fiber type specification) Although tipping paper is not intended to be burned, customers will occasionally let the cigarette be smoked into the filter. Flare-ups can occur when the components of the filler content are in certain proportions. Other variables may also influence flare-ups.

With the exception of electrostatic perforation, the type of tipping paper one chooses to perforate is not critical. The specifications needed for normal cigarette production are usually acceptable for perforation stock. However, it is a good idea to use low porosity tipping papers if they are to be perforated later. If not, you are adding another variable to the equation. Tipping papers over 30 ml/15 seconds have been known to create some ventilating problems. The reliability of your paper supplier's specifications is obviously a large factor in this. Figure D.-6 shows typical Philip Morris parameters.

It is important to cover in some detail the special requirements of tipping paper used for electrostatic perforation. A number of problems have been encountered in the past, leading to extensive research to find and eradicate the source of the problems. The following information relates to Philip Morris' experience with ESP and tipping paper, not necessarily to other systems.

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The critical components to monitor in the cork base sheets are iron oxide, clay, and titanium dioxide. The levels of iron oxide should not exceed 1%, while the latter two should not exceed 2%. They may all range to zero and be acceptable, ESP wise. Calcium carbonate at about 14% is ideal. It helps clean the electrodes. The big problem with the other agents is the build-up, or oxidation, they cause on the electrodes. This will result in breaks. TiO2 levels are especially critical, although opacity suffers when it is omitted. It is the inorganic compounds which adversely affect the electrodes. Azo dyes have replaced iron oxide as the cork base pigment for ESP paper. Research is continuing to eventually re-institute the iron oxide or other pigments in low calcium carbonate papers for ESP, instead of the Azo dyes.

Concerning the cork inks, standard inks have been found to leave deposits causing web breaks and/or variable charge levels. As a result, the specifications for the vehicle/pigment ratio were tightened to read between 60/40 and 75/25. Generally, the higher the vehicle, the better the ESP runs. A copy of the components in an acceptable ink is shown. Regarding binders, nitrocellulose is preferred to ethylcellulose because the spark burns quickly and cleanly. Ethylcellulose can leave charred edges around the holes.

With white base sheets, Philip Morris has removed the titanium dioxide and silicates (clays) completely. The basis weight has been dropped to 33 g/m^2. This increases perforating speeds by decreasing the mass through which the electrical charge must travel. The combination of these two measures decreased opacity significantly, from 91 to 80%. To partially offset this, the calcium carbonate level was increased to 20 - 23%. While

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this combination is much better than papers not specifically designed for ESP, the calcium carbonate still increases electrode deposits, hence web breaks. Subsequently, more problems are likely to be encountered when electrostatically perforating white base sheet than cork base sheet. The standard cork inks will perforate acceptably on white base sheet, eliminating the need for special vehicle/pigment ink types.

3. Plug Wrap

The role of plug wrap in the cigarette has evolved dramatically with the advent of ventilated cigarettes. Its original role was simply to prevent the cellulose acetate rod from expanding or otherwise deforming, after it was made. Plug wrap for a ventilated cigarette must still perform that function, plus refrain from impeding the filter tip ventilation. The only exceptions to this would be on-line ventilation, where both plugwrap and tipping are perforated at the same time, and cigarette rod ventilation. The degree of dilution is determined by the component with the lowest porosity. This is a very important point. It is usually the tipping paper that controls. In this case, the role of the plugwrap is to maintain a minimum (higher) porosity level while retaining good machinability properties. Plugwrap that exceeds porosity specifications will not affect dilution nearly as much as plugwrap that falls below the minimum porosity levels. This factor facilitates the consolidation of plugwrap inventories. It is definitely possible, though, to use a highly porous or perforated tipping paper and vary the plugwrap to control ventilation. This is discussed in Section G.

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The ideal situation would eliminate the plugwrap as a variable, leaving only the tipping paper to control the dilution level. This possibility does indeed exist. Non-wrapped acetate filters, or NWA as it is known, were developed by Filtrona, LTD. The attraction of such a system is obvious. Besides eliminating the cost of plugwrap, you will be removing a variable in the ventilation equation. Filtrona found the ventilation variability could be halved, to 6 - 10%, when using NWA vs. standard porous plugwrap. However, Philip Morris was unable to justify the use of NWA. The cost of the extra tow needed to make the rods more than offset the savings on plugwrap. The difficulty in running NWA, plus the variability of the rod circumference, proved to be a major problem during production. Still, it was discontinued at Philip Morris more for economic reasons than machinability problems.

What, then, makes a good plugwrap? What are the important criterion? Once again, until converting to a ventilated cigarette, there is no need to alter your current plugwrap. A standard plugwrap with porosity in the 10-50 ml/15 seconds is sufficient. However, any form of filter tip ventilation will require a porous plug wrap. For low levels of ventilation, a porous plugwrap in the 300-600 CORESTA range will work. Conventional porous plug wrap, using short wood fibers and standard paper making technology, managed to achieve these levels of porosity but with higher variability. Some also perforate the wrap, but this causes even higher variability. Perforated plugwrap is usually confined to use on cavity filters. Uniformity then, is probably the most important property of good plugwraps.

Plugwrap is usually cut into bobbins from 12 foot rolls. Considering

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

each cigarette uses a piece about one inch square, the importance of uniformity becomes more obvious. The big problem with changing to high porosity plugwraps was their inability to reach the necessary porosity levels, while maintaining low variability. This hurdle was crossed by converting to a non-woven process that vastly increased the range of porosities. The range increased 100 fold, from 500 to 50,000 CORESTA! Wet-forming non-wovens uses an inclined forming wire instead of a horizontal wire. This allows much longer fibers to be used than in conventional technology. Non-woven wrap uses longer, thinner fibers to create a base sheet that has a great many more pores, or open spaces. These fibers must be uniform in diameter and shape to be effective. Varying fiber types and parameters can alter the size and distribution of the pores. Simply increasing pore size, without changing the fiber sizes, decreases the bonding surface. Variability is inevitably higher too, due to a fewer number of pores controlling the permeability. Conventional paper-making processes are unable to function using the longer fibers needed for inherently porous papers. Hence the growth of non-woven methods.

Dexter Corporation was in a very good position to capitalize on the demand for porous and ultra-porous plugwrap. They have made teabag filter paper for many years. Plugwrap is very similar to this product. Schweitzer and Ecusta have also developed non-woven paper technologies, though Ecusta does not offer a plugwrap over 10,000 CORESTA. As mentioned above, varying the fiber types and sizes gives great flexibility to the paper permeability. They affect the tear resistance and paper strength. These features allow for clean cutting on the plugmaker, plus produce a more break-resistant plugwrap.

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To increase the bonding surface area of the fibers Dexter uses a process called "fibrillation". Fibrillation involves suspending the fibers in liquid and beating them. This agitation breaks the fibers into hairlike fibrils which entangle in the wet forming non-woven process to form a highly porous, yet very strong web. The pore size can be modified by altering the degree of fibrillation. Polymeric binders applied in a bath add to the plugwrap wet and dry strength. They have successfully claimed this process helps produce a highly porous plugwrap that is resistant to adhesive bleed-through. Bleed-through is the single biggest problem with porous, and especially ultra-porous plugwrap. Making an ultra-porous paper is not that difficult until the area of adhesive application is factored into the problem.

The plugwrap must have an affinity for the adhesive that allows it to penetrate into the fibers, yet not bleed-through, or come completely through to the other side of the fibers. A web that is too open can cause the adhesive to miss the fibers altogether. At the same time, fibers that are too resistant to the adhesive can cause poor bonding and foul the machinery with the glue run-off. This adhesive affinity, as it is called, is a function of all of the variables I have mentioned. Specifically, uniform pore size and special bonding treatments have been used to achieve it. Their importance in creating a good, machinable porous plugwrap cannot be overstated.

While conventional plugwraps have between 10 and 35% filler, non-woven plugwraps, both porous and ultra-porous, have none. Basis weight on regular plugwraps runs from 25-65 g/m^2, on an average. Porous and ultra-porous plugwraps have base sheet weights of only 18 - 26 g/m^2. Tensile strength is obviously lower on non-wovens. It generally

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holds true that the higher the porosity, the lower the tensile strength. Conventional plugwrap values run from 6 to 10 kg/3cm. Porous plugwrap under 2000 CORESTA can generally match low average standard plugwrap tensile strengths, but ultra-porous wraps are typically only half to two-thirds as strong.

Whatever the type of plugwrap you choose to complement the cigarette manufacture, there is currently a wide variety of quality products to select from. The advancements in plugwrap technology have greatly eased the problems associated with producing ventilated cigarettes.

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TYPICAL PHILIP MORRIS CIGARETTE PAPER PARAMETERS

POROSITY			BURNING CHEMICAL		FILLER	TAPPI OPACITY	TENSILE
Filtrona	Coresta	Greiner	Type	%	%	%	Kg/3cm
40	71.7	8.0	C	0.55	34	77	2.6
64	47.1	11.5	C	1.00	33	78	2.9
64	47.1	11.5	C	2.00	31	77	2.6
64	47.1	11.5	C	3.00	31	77	2.5
89	35.1	15.0	C	0.90	31	78	3.1
98	32.2	16.0	C	0.65	30	78	3.1
124	26.1	20.0	C	0.55	31	78	3.2
181	18.6	28.0	C	0.40	28	76	3.5
181	18.6	28.0	C	0.85	27	76	3.5

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CIGARETTE PAPER POROSITY CONVERSION CHARTS

BORGWALDT DE MAUDUIT L/H 20 cm^2 10 cm W.G.	CORESTA cc/mn cm^2 10 cm W.G.	SHEFFIELD SCHWEITZER cc/mn 3/4" Dia. 1.5 psi.	GREINER SCHWEITZER s/50 cc
180	150	420	
170	140	400	7,2
160	130	380	
150	120	360	7,5
140	110	340	
130	100	320	
120	90	300	8
110	80	280	
100	70	260	8,5
90	60	240	9
80	50	220	
70	40	200	10
60	30	180	11
50	20	160	12
40	10	140	13
30		120	14
20		100	15
10		80	20
		60	30
		40	40
		20	50

Because of experiences in individual Greiner instruments and the variation of the relationship between flow and pressure drop for different papers, a precise cross calibration is not possible among these testing methods. The chart above is a general correlation but may not be exact in any particular case.

June 1976

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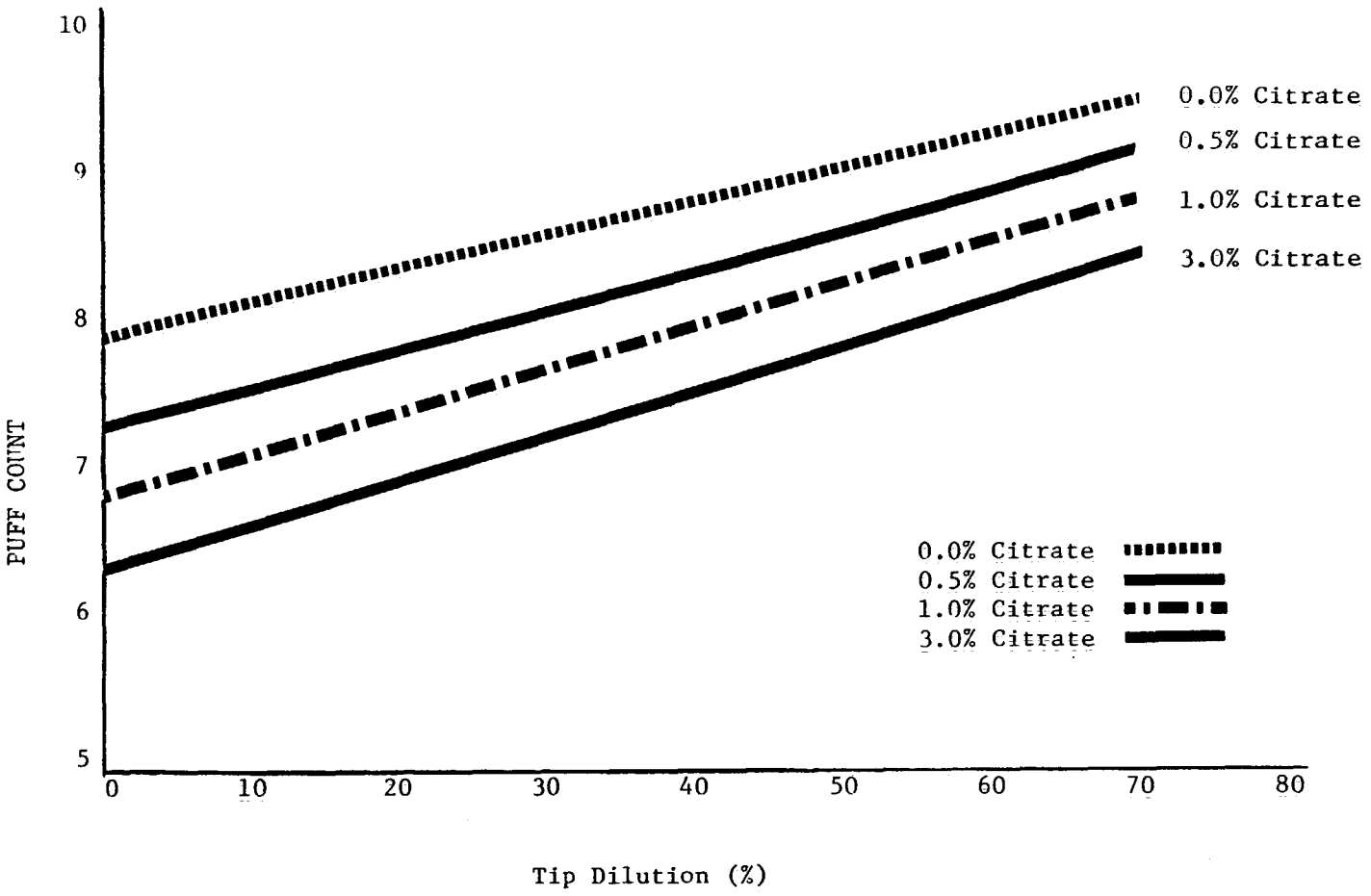
Figure D.-3

EFFECT OF CITRATE LEVEL ON PUFF COUNT



Data from Celanese

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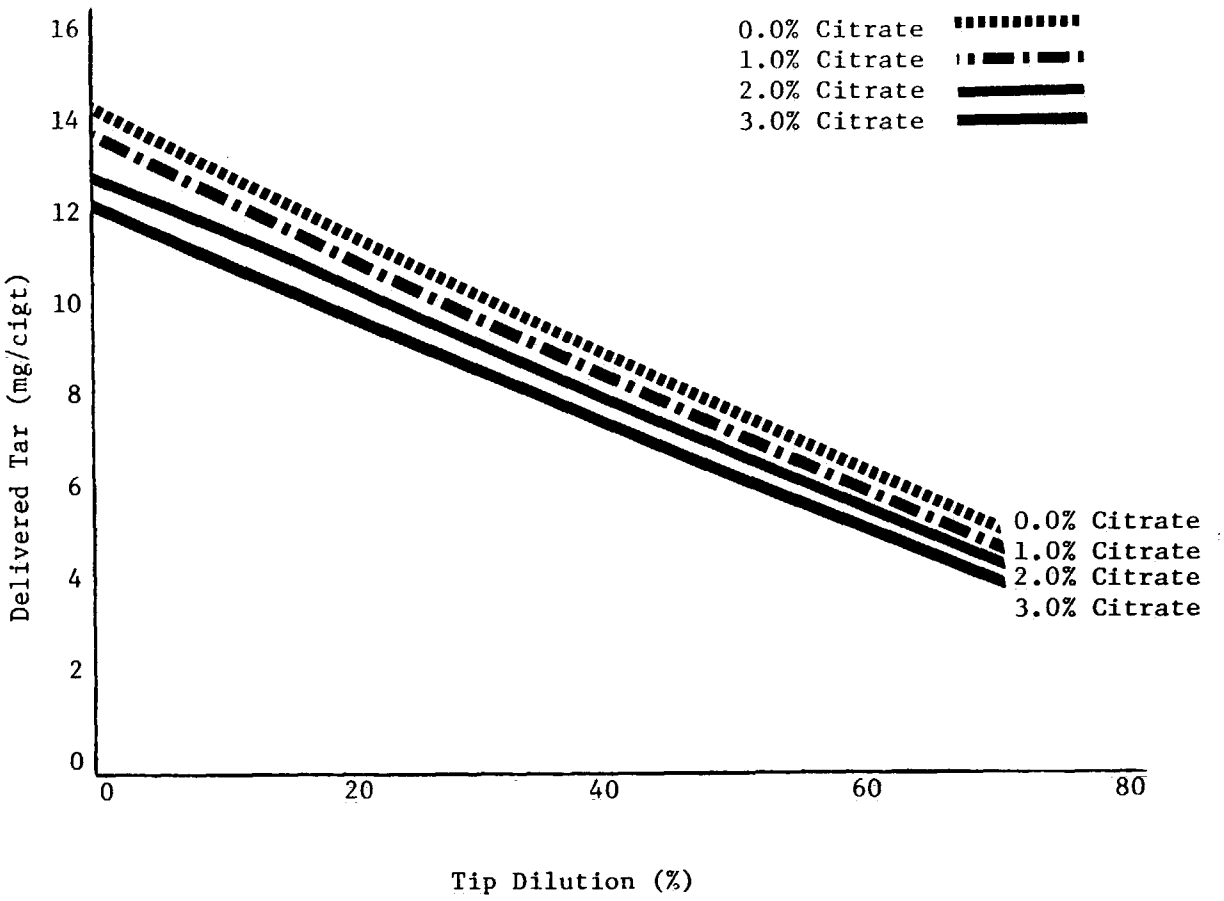
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure D.-4

TOTAL TAR DELIVERY REDUCTION



Data from Celanese

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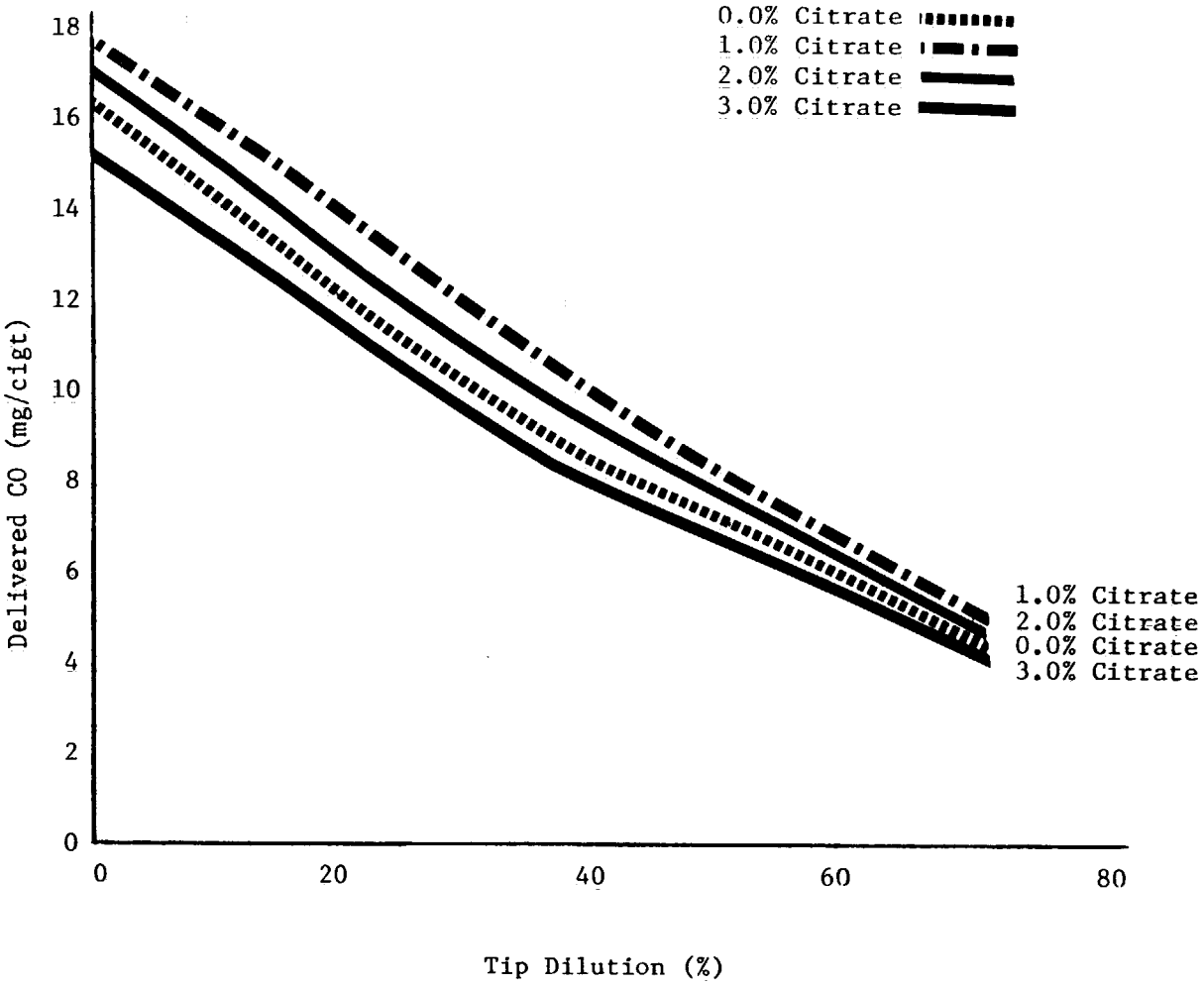
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure D.-5

TOTAL CO DELIVERY REDUCTION



Data from Celanese

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

BASESHEET COMPOSITION

FIBER (65 - 90%) - WOOD PULP

FILLER (10 - 35%) - MINERALS

CALCIUM CARBONATE - $CaCO_3$, CHALK

- OPACITY, WHITENESS

TITANIUM DIOXIDE - TiO_2

- OPACITY, WHITENESS

ALUMINUM SILICATES - CLAY

- OPACITY (NON-WHITE SHEETS)

IRON OXIDE - Fe_2O_3

- PIGMENT FOR CORK SHEET

ORGANIC DYES - CORK BASESHEET

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TYPICAL PHILIP MORRIS TIPPING BASE PAPERS

	BASE WEIGHT G/m^2	POROSITY ml 15 Seconds	FILLER %	BRIGHTNESS %	TAPPI OPACITY %	TENSILE Kg/3 cm.
Cork Tipping	32	20	18	N/A	90	7.3
White Tipping	34	15	33	89	89	6.5
	40	4	35	92	89	8.5
	38	6	35	92	89	8.0

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CORK BASE SHEET FOR ESP

COMPONENT	DESIRED LEVEL	MAXIMUM LEVEL
Fe_2O_3	0% to trace	1%
Clay (Silicates)	0% to trace	2%
TiO_2	0% to trace	2%
$CaCO_3$	13 - 15%	-

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CORK INKS

PIGMENT (25 - 75% OF SOLIDS)

IRON OXIDE

CLAYS

TITANIUM DIOXIDE

CARBON BLACK

VEHICLE (25 - 75% OF SOLIDS)

NITROCELLULOSE* (BINDER)

MALEIC RESIN (BINDER)

PLASTICIZERS

WETTING AGENTS

SOLVENT

ETHYL ACETATE

METHYL ETHYL KETONE

*LIP RELEASE AGENT FOR WHITE TIPPINGS

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TIPPINGS FOR ESP

	CORK	WHITE (what kind do Decians)
BASIS WT. (G/M^2)	33	33
OPACITY (%)	93	80
% ASH, 525°C	15	25
% ACID - INSOLUBLE ASH	1	2
$\%CaCO_3$	14	23
$\% TiO_2$	0.5	1
% CLAY	0.5	1

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TYPICAL PHILIP MORRIS PLUGWRAP PARAMETERS

REGULAR

BASIS WEIGHT G/M^2	POROSITY ml/15 Sec.	FILLER Per Cent	TENSILE Kg/3 cm
35	40	22	6.2
65	30	34	10.0
26	16	12	6.9

POROUS & ULTRAPOROUS

	CORESTA		
25	600	None	7.7
26	3,300	None	4.8
20	26,000	None	4.3

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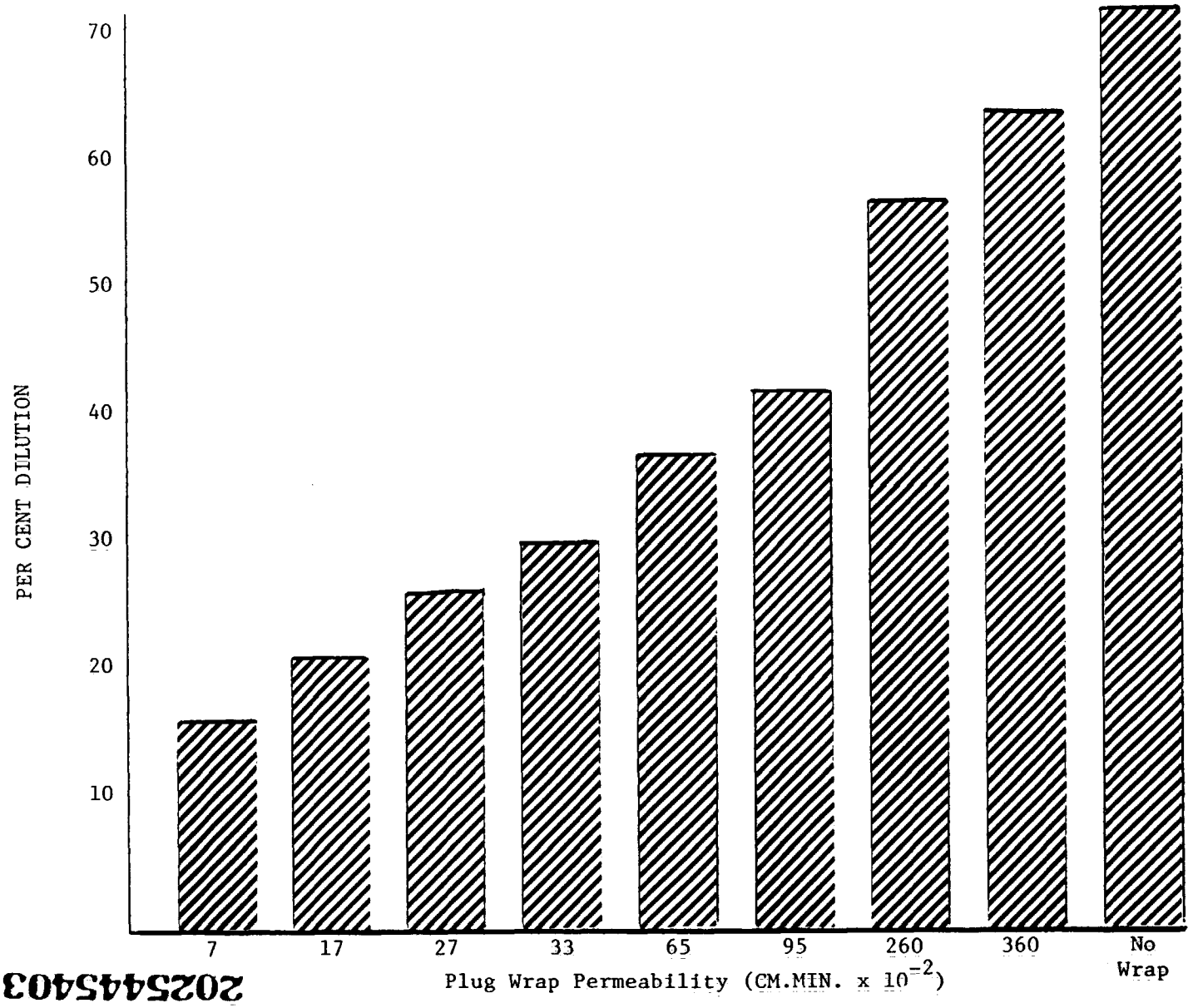
* PLUGWRAP VS. DILUTION -
MACRO TIPPING, PLUGWRAP CONTROLLED



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* Simplified presentation. Actual design calculations more complex.
Data from Sweitzer

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

E. MATHEMATICAL MODEL FOR CALCULATING VENTILATION

1. Explanation of Model

Slide E-1 shows schematically the ventilation processes in the static state that occur in a cigarette. It also shows the various pressure drop measurements necessary to calculate the percent dilution. ΔP_o is the pressure drop of the cigarette unencapsulated with the vents open. ΔPe is the pressure drop of the cigarette encapsulated with the vents closed. ΔPc is the pressure drop of the cigarette filter encapsulated, with vents closed. ΔPf is the pressure drop of the filter encapsulated with vents closed. All pressure drop measurements are made at the standard flow rate of 17.5 cc/sec or 1050 cc/min. Slide E-2 shows the equations for calculating percent ventilation from pressure drop measurements. Pressure drop ΔP is equal to the product of an impedence coefficient, flow rate and length. The impedence coefficient for a particular cigarette is a function of the design of the cigarette, and the inherent resistance to air flow based upon cigarette design. The general relationship $\Delta P = K \cdot Q \cdot L$ is used as the basis for calculating percent dilution. Percent dilution = $\Delta Q/Q \cdot 100\%$, or diluting flow divided by exit flow. Percent dilution may also be defined as $\frac{\Delta Pc - \Delta Po \times 100}{\Delta Pc - L1\ \Delta Pc/Lf}$.

The percent dilution is equal to the Cigarette Pressure Drop, filter encapsulated (ΔPc) - the Cigarette Pressure Drop Unencapsulated (ΔPo) divided by the term Cigarette Pressure Drop, filter encapsulated ΔPc - Filter Length from the mouth end of the cigarette to the vents Ll times the Encapsulated Filter Pressure Drop ΔPf divided by the total Filter Length Lf. The term $Ll\,\Delta Pf/Lf$ has the effect of

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subtracting out the pressure drop of the filter length from vents to mouth end. This portion of the filter has no effect on ventilation since it presents no resistance to air flow upstream of the vents. The logic for the pressure drop of this section of the filter is that pressure drop of a filter is directly proportional to the length. Ll/Lf, the fractional portion of the filter from the vents to mouth end, times ΔPf, the total encapsulated pressure drop of the filter, gives the pressure drop contribution of length Ll. The equation just described covers the calculation for one row of perforations.

For multiple rows of perforations the additional term in the denominator, N - 1/2 ΔL ΔPf/LF subtracts out 1/2 of the filter length covered by the perforation band.

This method is applicable where a direct method of measuring ventilation is not possible. The short-coming is that pressure drops are measured at a fixed and continuous flow. The equation assumes that ventilation is not a function of flow rate, but pressure drop.

Another use for these calculations is that the effect of moving vent location or varying the number of rows and varying band widths, as illustrated by equation 2 for multiple rows of holes, may be predicted. It is also possible from this model to determine what level of encapsulated pressure drop is necessary to achieve a desired level of unencapsulated pressure drop at a given level of ventilation.

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2. Comparison of Calculated to Measured Dynamic State

In the previous section, the model for calculating ventilation from pressure drop measurements was shown and explained. A method for measuring dynamic state ventilation will be explained and compared to calculated values in this section.

A schematic diagram of a spirometer for measuring ventilation is shown in slide E-3. A double dental dam holder is used to interface the spirometer to the ventilation system and to permit ventilation measurements to be taken. The displacement of a soap bubble in the spirometer measures the amount of air that enters the vents during a standard 2 sec. 35 ml puff. The spirometer permits the measurement of ventilation during a puff or in the dynamic state, rather than simply the static state with steady flow. It is therefore possible to measure ventilation for a lit cigarette. Since the pressure drop created by the burning coal will create additional total cigarette ΔP up stream of the vents, ventilation should increase when measured in the dynamic state. From data in slide E-3, the internal resistance to air flow of the spirometer has prevented this expected effect.

Slide E-4 shows a comparison of calculated values for ventilation and spirometer readings. Note that the values for low levels of ventilation are in good agreement. The values for cigarette D do not agree closely. For high levels of ventilation, the resistance to air flow of the spirometer works in series with the pressure drop of the vent system, which affects the flow of air through the vents.

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3. Comparison of Calculated to Measured Ventilation, Dynamic and Static State

A third method of determining the degree of ventilation is measuring with the Philip Morris Digital Dilution Instrument. This instrument is combined with the Philip Morris Pressure Drop Instrument. This instrument will be described in detail during the Q.A. section of this presentation. The purpose here is only to describe briefly the measurement of ventilation for the purposes of comparing measured values to calculated values. Slide E-5 shows a schematic of the operations performed by the DDI.

Ventilation is the percent of total 1050 cc per minute of air flow that enters the cigarette over a defined ventilated area. The dilution measuring head uses lip seals at both ends of the area to define the area over which air may enter the ventilation system. The percentage of air is determined by measuring the pressure drop across the laminar flow element with a differential pressure cell. Millivolt signals corresponding to the position of the transducer diaphragm in the "DP" cell are sent to a demodulator. The demodulator converts the millivolt signals to a 0 - 10 volt signal which represents a scale of 0 - 100% ventilation. A digital volt meter displays the ventilation reading.

Slide E-6 shows a comparison of calculated ventilation, spirometer-dynamic state ventilation, and PDI Instrument measured ventilation. In all cases the calculated values are higher than the measured values. However, the differences are all within $\pm$ 5% which is our normal target range.

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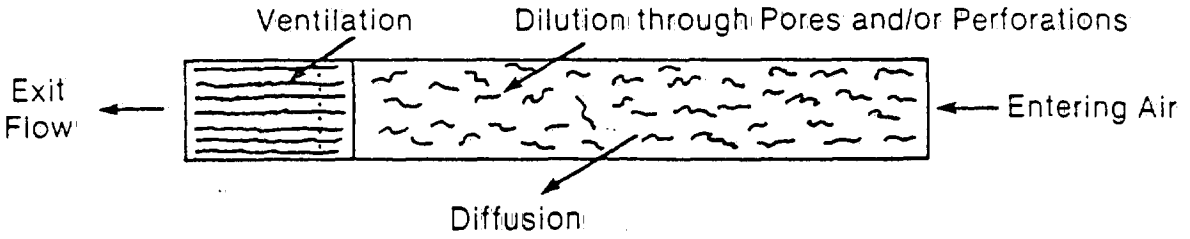
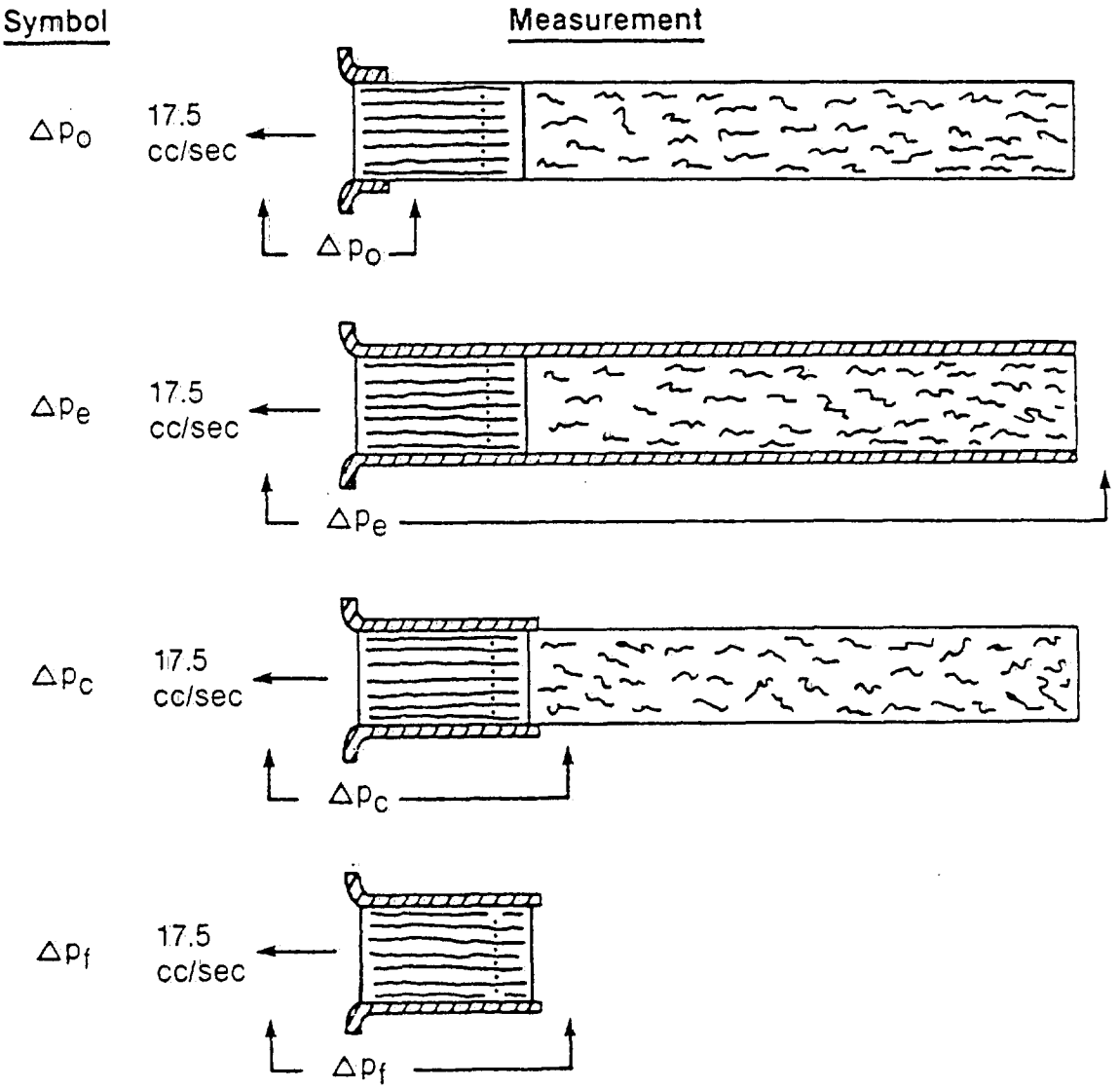
Figure 1





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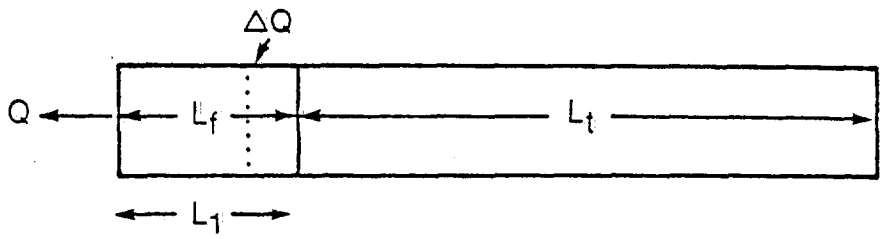
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure 2

CALCULATION OF DILUTION FOR VENTILATED FILTERS

1. Single row of holes:



By using the general relationship:

$\Delta p = K \cdot Q \cdot L$

Where: Δp = pressure drop
K = impedance coefficient
Q = flow
L = length

We get:

$$\text{Percent Dilution} = \frac{\Delta Q}{Q} \times 100 = \frac{\Delta p_C - \Delta p_O}{\Delta p_C - L_1 \Delta p_f / L_f} \times 100$$

Where: ΔQ = Diluting Flow (cc/sec)
Q = Exit Flow (cc/sec)
Δp_C = Cigarette Pressure Drop, filter encapsulated (mm H_2O)
Δp_O = Unencapsulated Cigarette Pressure Drop (mm H_2O)
Δp_f = Encapsulated Filter Pressure Drop (mm H_2O)
L_1 = Length from Mouth End to Vent Holes (mm)
L_f = Filter Length (mm)

2. Multiple Rows of Holes:

$$\text{Percent Dilution} = \frac{\Delta p_C - \Delta p_O}{\Delta p_C - L_1 \Delta p_f / L_f - \left(\frac{n-1}{2}\right) \Delta L \, \Delta P_f / L_f} \times 100$$

Where: n = Number of Rows of Holes
ΔL = Distance Between Rows of Holes (mm)

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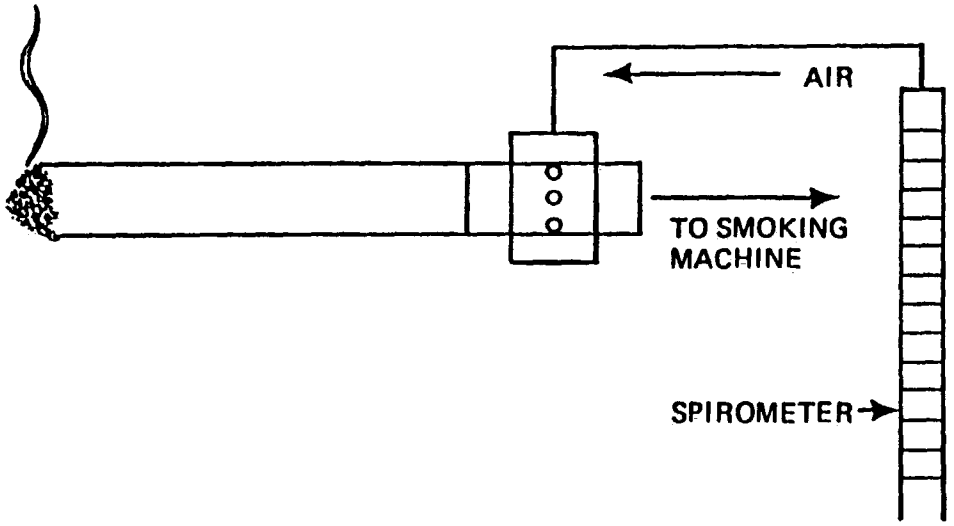
SCHEMATIC DIAGRAM OF SPIROMETER MEASURING DEVICE



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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

COMPARISON OF MEASURED AND CALCULATED VENTILATION VALUES

CIGARETTES	PERCENTAGE VENTILATION	
	SPIROMETER	CALCULATED
A	21	21
B	27	29
C	63	67
D	71	83

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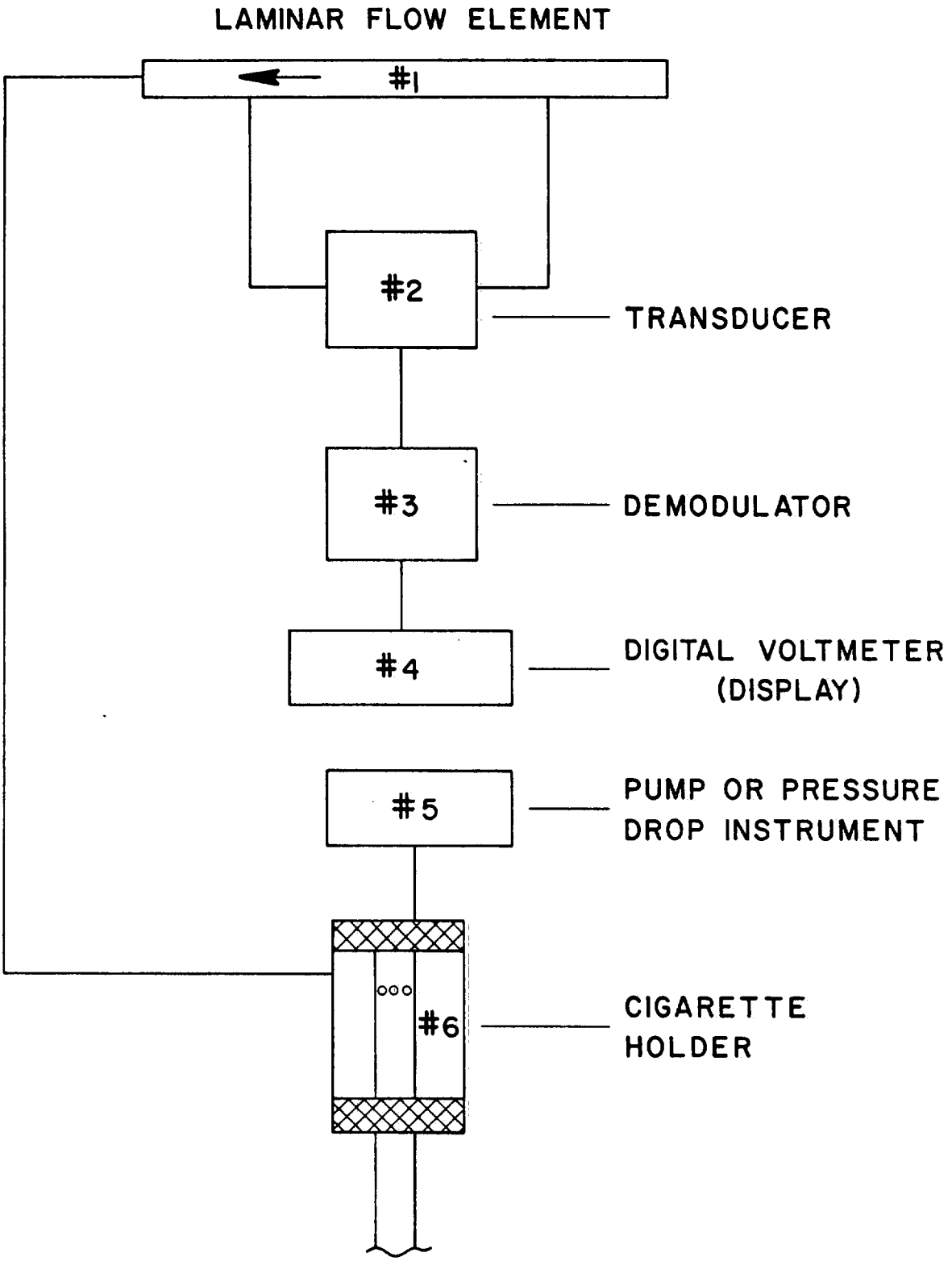

FIGURE II

SCHEMATIC - DIGITAL DILUTION INSTRUMENT

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COMPARISON OF DILUTION METHODS (%)

CALCULATED	SPIROMETER	PM INSTRUMENT
17	15	15
26	23	24
54	49	52
79	75	78
86	82	85

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F. Effects of Ventilation

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

F. The Effects of Ventilating Cigarettes

1. Smoke Formation

Any discussion of the effects of ventilation should be preceded by a discussion of the basic principles involved when a cigarette is lit and smoked.

The lighting puff forms the coal. Two burning processes are established for a cigarette, puffing and smoldering. During puffing, air is drawn through the coal, forming mainstream smoke. Between puffs, air is moved upward around the coal and sidestream smoke is formed. Mainstream and sidestream smoke consists of a particulate and a vapor phase. Tar, nicotine, and H_2O are the major components of the particulate phase. The vapor phase is composed of gases from the air and from the combustion process. Nitrogen, oxygen, CO, CO_2 and water vapor make up most of the vapor phase.

When a cigarette is puffed, the tobacco and paper are burned incompletely in the presence of oxygen, yielding tar vapor, water, and gases. Complete combustion would yield only CO_2, H_2O and NO. The peak temperature for this process is 850°-900°C.

The gaseous mixture cools quickly. Condensation results in the formation of the particulate phase of the smoke aerosol. As the aerosol is drawn through the tobacco column and filter, filtration of the particulate phase occurs mainly in the filter.

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Immediately behind the coal, a pyrolysis zone is created, due to coal heat and the high temperature generated by the gases. This zone will become the coal for the next puff. Stable volatile compounds such as nicotine, menthol and water are distilled into the mainstream smoke. Thermal decomposition products, such as aldehydes, ketones and acids become part of the mainstream smoke in this zone. Between puffs, sidestream burning takes place in a relatively 0_2 rich atmosphere. Because of this 0_2 rich environment, almost twice as much tobacco is consumed during the time between puffs compared to during the puff. The formation of more H_20 and CO_2 and less tar in the smolder time indicates more complete combustion.

To summarize, CO and CO_2 are formed by combustion and pyrolsis. Most organics are formed by pyrolsis and pyrosenthesis in the pyrolsis zone. Prerequisites for the formation of the organics are high heat of combustion and the lack of oxygen in the pyrolsis zone.

2. Mechanisms of Ventilation

a. Experiments

Slide F-1 shows the effects of air dilution. The end result of ventilation is a reduction of delivered smoke and smoke components to the smoker.

This is achieved through two basic occurences when the cigarette is ventilated.

1. The introduction of atmospheric air into the mainstream smoke reduces the per puff smoke concentration.

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2. Modified burn rate of the tobacco. The higher the ventilation, the more the burn approaches the likeness to static burn.
3. Less tobacco is consumed per puff which increases the puff count.
4. Gases such as CO, and NO diffuse outwardly through the porous cigarette wrapper as a result of slower aerosol velocity.

To elaborate on the per puff reduction of smoke concentration, we will refer to results of experiments performed by C. L. Brown, C. H. Keith and R. E. Allen of Celanese Fibers Co. Cigarette columns were prepared using a typical U.S. tobacco blend and Ecusta 556 cigarette paper, a 20 sec. Greiner porosity paper, and cut to 60 mm length. The 25 mm vented filters used were obtained from commercial cigarettes. The columns were conditioned for 48 hours at 74 ± 2^{o} F and $60 \pm 2\%$ relative humidity and weight selected. The degree of filter ventilation was calculated using the pressure drop method as presented earlier. The cigarettes were smoked under standard smoking machine conditions to a butt length of 33 mm.

Slide F-2 shows calculated mainstream smoke as a function of ventilation. This slide is shown here to illustrate what happens to the puff volume at the cone. Note from the horizontal scale that as ventilation increases from 0 to 100 percent, the puff volume at the cone changes from 35 cc to 0 cc.

Data for the mainstream particulate phase is shown in Table 1. Table 1 shows that when the cigarettes were machine smoked with a standard 2

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sec. puff @ 17.5 cc/sec. flow rate, the percent dilution varies from 0 - 83%, there is an increase in the number of puffs, a decrease in puff volume at the cone, and a decrease in Total Particulate Matter, that is, a decrease in delivered water, nicotine, and tar. As shown schematically by the graph presented in the previous slide, delivery decreases could be predicted as a function of decreasing puff volume at the cone with increasing levels of ventilation. The effect of puff volume at the cone was confirmed by holding the puff duration constant at 2 seconds and varying puff volume from a low of 17.5 cc to a high of 50 cc. This was with and without 33% filter dilution. With the exception of the 17.5 ml puff with zero dilution, there was good correlation between puff volume at the coal and mainstream particulate phase deliveries.

Table 2 shows the mainstream vapor phase deliveries. Carbon monoxide, carbon dioxide and nicotine show a continuous decrease as the ventilation level is increased. Water shows a downward trend but the results are not clearly defined. Note at the standard puff volume, from 33% to 48%, then on to 83% dilution, the water actually increased.

Table 3 shows the sidestream particulate phase data. Also shown is free burn data which was collected by taking a lighting puff, then allowing the cigarette to free burn to a 33 mm butt length. Total Particulate Matter, condensate, and nicotine deliveries increase a small amount with increased ventilation, while particulate water decreases slightly.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

The reductions in tar and carbonmonoxide, and the increase in CO_2, show that combustion is more efficient during the free burn, or during the interval between puffs than during puffing.

Sidestream vapor phase data is presented in Table 4. Carbon monoxide and nicotine appear to increase somewhat with ventilation, while carbon dioxide shows a definite increase. This indicates more efficient combustion. The water in the sidestream vapor phase appears to be unaffected by ventilation.

Table 3 and 4 taken together clearly show that there is an increase in vital delivered material in the sidestream as ventilation increases. This is a result of more tobacco being consumed during the puff interval relative to the puff itself and more complete combustion during the puff interval.

Table 5 shows the total delivery, mainstream and sidestream or the summation of mainstream and sidestream delivery. The conclusions that can be drawn from table 5 are:

1. As puff volume at the cone decreases, the puff count increases.
2. Going from puffing to free burn, at 0% dilution, will reduce the condensate or tar approximately 50%, 46.9 mg to 23.4 mg. CO_2 is increased by 20% and CO is reduced 15%.
3. The total delivery of nicotine and water, which are distillation and pyrolitic products, are changed very slightly by filter ventilation.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

The following table 6 shows the grams of tobacco (mg/g) consumed during puffing. Table 7 will show consumption during the puff interval. These consumptions were derived by using the nicotine in the sidestream from the lighting puff down to the 33 mm butt length. It includes free and static burn. Since the weight of the column and nicotine content of the tobacco and sidestream nicotine were known, it was possible to calculate grams of tobacco consumed in generating the nicotine in the sidestream. Grams consumed during puffing is the difference between the total consumed and what was consumed during the puff interval.

From table 6, mainstream deliveries of condensate, nicotine and CO_2 do not appear to change significantly with varying degrees of ventilation, based upon mg per gram of tobacco consumed. Mainstream CO and H_2O decrease significantly, which further indicates that lower aerosol velocity, along with increasing dilution, enhances outward diffusion of gases. Table 7 indicates the same is true for sidestream deliveries.

b. Conclusions

The following conclusions can be drawn from the experiments performed by Keith and others:

1. The burning process is altered by ventilation. As ventilation levels increase, burning becomes more similar to static burning. This reduces tar and CO and increases CO_2.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

2. Increasing ventilation decreases puff volume at the coal. Reductions in deliveries of most components are related to puff volume at the coal.
3. Increasing air dilution decreases the deliveries of all mainstream components in a linear fashion. Increasing ventilation gives less CO and H_2O, the same amount of CO_2, and more nicotine, relative to condensate in the mainstream.
4. Increasing ventilation shows relatively constant amounts of distillable components such as H_2O, nicotine and condensate in the sidestream, CO and CO_2 increase, CO_2 considerably more than the former.
5. Per gram of tobacco burned the delivery of all components in the sidestream are essentially constant at varying ventilation levels. In the mainstream, condensate, nicotine and CO_2 appear to be constant while CO and H_2O decrease with increasing ventilation levels. The results on per gram burned basis serve as evidence that the combustion process is altered and that outward diffusion of gases such as CO and H_2O increase with increasing ventilation.
6. Sidestream combustion is more efficient than mainstream combustion. Twice as much CO_2 and approximately 3.2 times as much H_2O is formed in sidestream as in mainstream.

3. Reduction of Various Smoke Components

The series of slides that follows will show the percentage reduction of various smoke components as a function of percent ventilation. As previously mentioned, these reductions are attributed to:

1) Reduced smoke production as a result of reduced puff volume at the coal and,
2) Reduced aerosol velocity.

Reduced aerosol velocity increases smoke residence time and results in greater opportunity for gases to diffuse outwardly. Reduced aerosol

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

velocity also increases the filtration efficiency and modifies the burn rate so that less tobacco is consumed per puff.

The graphs that follow contain data that was generated by smoking 85 mm cigarettes made with 21,25 and 26 mm filters using 2.1/55k, 3.4/46 K and 5.0/46 K #10 cross section tow. The cigarettes were ventilated at various levels and each series was smoked against a control with 0% ventilation.

The cigarettes were smoked to 28, 32 and 38 mm butt lengths per 21, 25 and 31 mm filters, respectively. For the first three graphs in each section, the data is presented for 21, 25 and 31 mm filter lengths combining tow items. The second set of three graphs for each section presents data for each of the three tow items and combines length data. While other factors enter in to reductions of components, the important emphasis here is the effect of ventilation.

a. Particulate Phase Reductions

1. Total Particulate Matter

Total Particulate Matter (TPM) is defined as the material remaining on a Cambridge Filter Pad after smoking a specified number of cigarettes, using the constant volume automated smoking machine. TPM includes primarily FTC Tar, nicotine, and H_2O but also includes other components absorbed on the Cambridge filter pad having a particle size greater than .3 microns. The following graphs show the relationship between TPM reduction and ventilation.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TPM reduction efficiency is dependent upon the level of ventilation and the filter length. It varies from 70-100% of the actual ventilation level.

The first three graphs represent % TPM reduction vs ventilation levels for 21, 25, 31 mm filters, using 5.0/46,000, 3.4/46,000 and 2.5/51,000 #10 Filter Tow. Notice the upward shift of the line between Figure 1 for a 21 mm filter and Figure 2 for a 25 mm filter. the graph for the 25 mm and 31 mm filter are approximately equal. The TPM Reduction efficiency varies from 70% for the 21 mm filter at 10% ventilation, to 100% for the 25 and 31 mm filters at 10%, 40%, and 60% ventilation levels.

The second set of three graphs varies the tow items, 2.5/51,000, 3.4/46,000 and 5.0/46,000 #10 and combines 21, 25 and 31 mm filter length data. Note that there is very little difference in the slope of the best fitted line for the three tow items. The TPM Reduction Efficiency varies from 80% for 3.4/46,000 @ 10% dilution to 100% for 2.5/51,000 tow @ 40% and 60% dilution levels and 3.4/46,000 tow @ 100% dilution levels.

TPM Reduction efficiency is dependent upon filter length, but as shown by the graphs, it is more dependent on the level of dilution for the three filter lengths studied.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

The decrease in TPM with units increasing ventilation can be attributed to greater filtration efficiency of the filter and filler as a result of slower smoke aerosol velocity. TPM is also reduced because of lower puff volume at the cone, meaning that less tobacco is consumed during puffing.

TPM reduction follows very closely the 1:1 relationship, as would be predicted from the level of ventilation.

2. FTC Tar

FTC tar is defined as total particulate matter minus nicotine and water and is expressed as mg/cigarette. FTC tar is calculated as follows:

FTC (mg/cigarette) = A - (B + C)

A = Total Particulate Matter (TPM) in smoke, mg/cigt.

B = Nicotine in TPM, mg/cigarette

C = Water in TPM, mg/cigt.

The first three graphs show the tar reduction percent for 21, 25, and 31 mm filters with data for the three tow items combined. Tar reduction efficiency varies from 70% for a 21 mm filter at 10% dilution to 100% for a 25 mm filter at 10% dilution and 31 mm filter at 10% dilution. The tar reduction efficiency is dependent on filter length. However, it is apparent from the graphs that percent tar reduction is more related to the level of ventilation.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

The second set of three graphs varies the filter tow item and combines data for 21, 25, and 31 mm filter lengths for the three tow items. There is very little difference in the slope of the graphs for the various tow items. This further points out that the tar removal efficience are more dependent upon the ventilation levels. Tar reduction with ventilation is a result of decreased smoke volume at the cone, and greater filtration efficiency resulting from decreased aerosol velocity.

The next two slides summarize the effect of ventilation on tar delivery. Notice on this slide that at approximately 70% ventilation, the level of reduction starts to approach the 1:1 relationship that would be predicted by percent ventilation. At approximately 75% ventilation, the reduction is actually greater than 1:1. The next slide graphically illustrates this phenomenom.

The final slide shows the effect of ventilation on tar delivery. By plotting the ratio of each factor affecting tar delivery for a non-vented versus a vented cigarette, it is possible to determine which factor has the most effect.

The higher than expected deliveries of tar at 75% ventilation or less is due to increased puff count. At ventilation levels above 75%, tar reduction is greater than 1:1. This slide indicates that filtration efficiency as a result of lower aerosol velocity and decreased puff volume at the cone more than counterbalanced the effect of increased puff count.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

3. Nicotine

Nicotine is one of the few liquid alkaloids. The graphs in this section show the relationship between filter ventilation for specified filter lengths and different tow items. The data shows that as the level of ventilation increases, the nicotine reduction increases. Nicotine reduction efficiency is percent nicotine reduction divided by ventilation. It is dependent on the filter length and the level of ventilation. The fact that nicotine is a stable distillation product will help explain some of the observations noted in the graphs.

From the data presented, it can be concluded that as percent ventilation increases, the percent reduction of nicotine increases. The percent reduction is considerably less than the 1:1 stoichiometric relationship that would be expected. At slower aerosol velocities with increasing levels of ventilation, the distillation of nicotine is more efficient.

Nicotine reduction at all ventilation levels is less than what would be predicted from the effect of ventilation. The explanation for this is likely to be that the distillation of nicotine is more efficient at decreased smoke aerosol velocity and portions of the nicotine previously filtered out of the aerosol are re-eluted or re-distilled back into the smokestream. Nicotine reduction efficiency for the ventilation levels chosen indicate that the reduction efficiency is dependent upon the level of ventilation and the filter length. It increases as the level of ventilation increases.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

The final graph summarizes the effect of ventilation on delivery of nicotine. At about 80% ventilation, the expected effect of ventilation on nicotine reduction is realized.

4. Nicotine to Tar Ratio

The nicotine to tar ratio increases with an increase in ventilation. As previously mentioned, tar has a condensable phase and the slower aerosol velocity caused by ventilation enhances the filtration of tar. Nicotine is a distilled, stable compound, and at slower aerosol velocities, nicotine distillation is more efficient, leading to the redistillation of previously filtered nicotine. As a result, the ratio of nicotine to tar increases with increased ventilation. Graphs in this section illustrate that as percent ventilation increases, the nicotine to tar ratio increases.

This next slide summarizes the effect of ventilation on the nicotine to tar ratio. Note at 0% ventilation, the nicotine to tar ratio is .06, while at 50% ventilation the ratio is approximately .072. This represents an increase in the ratio of approximately 16%. More efficient distillation of nicotine behind the coal is achieved due to lower puff volumes caused by ventilation. Less Nicotine is pyrolyzed and less is lost in the sidestream. There is now more nicotine in the smoke being presented to the filter. More nicotine that was previously deposited on the filter is re-eluted into the smoke as a result of reduced aerosol velocity.

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5. Water in TPM

The graphs in this section show the effect of ventilation on water

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

in TPM. Water is extracted from TPM with isopropyl alcohol and analyzed by gas chromatography.

In general, as the percent ventilation increases percent water in TPM decreases. The following graphs illustrate this point. It appears that water reduction is more dependent on the ventilation level than on filter length.

b. Gas Phase

The graphs in this section will demonstrate the relationship between the percent ventilation and the percent reduction of various gas phase components. In general the graphs illustrate that as filter ventilation increases, the amounts of various gas phase components decrease. In general, carbon monoxide (CO), and aldehydes (R CHO) reduction efficiencies are essentially 100% of the level of ventilation. At higher ventilation levels, CO reduction efficiency is higher than the 100% since diffusional losses are greater due to decreased aerosol velocity. The reduction efficiency for Hydrogen Cyanide is about 100% or more of the ventilation level. The NO reduction efficiency increases with increasing ventilation levels. However, the reduction efficiency of NO depends on filter length.

1. CO

The data presented in these graphs indicate that the reduction in CO with increasing ventilation levels is very efficient. It is quite evident that the reduction is greater than the 1:1 ratio as would be predicted if percent ventilation were the only factor involved. It might be suspected that the greater than expected reductions are due to the alteration of the combustion process. As will be

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

seen later, diffusional losses account for the largest part of CO reduction.

This slide shows the effect of ventilation on CO concentration. The dotted line represents the 1:1 line which would be the concentration of CO vs. ventilation if venting the cigarette were the only cause of the reduction in the concentration of CO. The fact that the actual delivery line for CO vs. percent ventilation is below the 1:1 line points out that there are other factors affecting the CO concentration. One of the other factors, as pointed out earlier, could be the changes in combustion, meaning less tobacco is consumed per puff. This results in less concentration of components in the smoke aerosol. The second effect is decreased aerosol velocity resulting in greater travel time of the smoke through the rod. This would allow greater CO diffusion outwardly through the tobacco column wrapper.

This slide shows the CO reduction vs. ventilation level on the per puff basis. Notice that the CO concentration of puff no. 2 for the nonvented cigarette is 4.1%. The CO concentration of puff number 2 for the vented cigarette @ 76% ventilation is .5%. This represents an 89% reduction for puff number two nonvented versus vented. For the last puff, the nonvented had 7.5% CO, while the vented had 1.7%, a 77% reduction. For the total cigarette, the average unvented per puff CO concentration was 5.6%, the vented 1.1%, or an average per puff reduction of 80%. From this slide, two important conclusions may be drawn:

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

1. The second puff reduction is greater than the last puff reduction, indicating that CO reduction was greater than 1:1 on the 2nd puff, but not the last puff. This supports the reasoning that diffusion is responsible, since the smoke travel distance and retention time in the cigarette is greater for puff 2 than the last puff. This would allow greater outward diffusion of CO for puff number 2 than the last puff.
2. These results also show that the overall reduction of 80% as opposed to 76% ventilation is greater than the expected 1:1, further indicating that the reduction in CO is supported by factors other than the percent ventilation.

2. NO

The next series of graphs show the reduction of NO as a function of ventilation. It appears that at approximately 60% ventilation, the reduction exceeds the 1:1 reduction expected from the level of ventilation. These reductions are explained, as with CO reduction, by increased diffusion of NO through the tobacco column wrapper caused by decreased aerosol velocity. Relative to CO, NO is reduced at a lower rate.

3. Other

The percent HCN (hydrogen cyanide) reduction is generally close to 1:1 as would be predicted. However, the HCN reduction efficiency is dependent on filter length. For the graphs shown, percent HCN reduction generally increases as the filter length increases.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

The reduction of aldehydes (RCHO) in the smoke generally follow a 1:1 reduction with percent ventilation. As filter length increases the percent reduction increases.

The next slide shows in general the reductions of gas phase components without regard to filter length and tow item. Notice that CO reductions are generally straight line with level of ventilation, but are higher than the 1:1 predicted from ventilation. This is due, as previously mentioned, to increased outward diffusion of CO. At approximately 60% ventilation, NO reductions become greater than 1:1. In general HCN and RCHO's are reduced are reduced about 1:1 which indicates in this case they also have increased diffusional tendencies with increasing ventilation.

4. Changes in Cigarette Parameters

a. Puff Count

Puff count is defined as the number of puffs taken when a cigarette is smoked to a prescribed butt length, using a 2 sec, 35 cc puff for a two second puff duration.

In general, puff count increases as percent ventilation increases. The puff count increase is due to decreased aerosol velocity or reduced puff volume at the cone resulting from ventilation. Less tobacco is consumed per puff consequently, puff count is increased.

b. RTD

Resistance to draw is defined as the pressure developed by the length of the cigarette when air is pulled through at the standard air flow of 1050 cc/min. The graphs in this section show that as percent

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ventilation increase, total unencapsulated cigarette RTD decreases.

These graphs and graphs generated for other tow item and filter length combinations are useful as guidelines to determine what effect a change in ventilation level will have on total cigarette RTD. If maintaining cigarette RTD at a constant level or within a certain range is an important design criteria, you may use these graphs along with capability curves and filtration efficiency curves to determine the encapsulated filter RTD necessary to maintain constant diluted cigarette RTD. They can be quite useful in establishing a new filter design within the required RTD range.

The following graph illustrates the effect of ventilation on the ratio of unencapsulated cigarette pressure drop to encapsulated cigarette pressure drop for different perforation systems. By dividing the unencapsulated cigarette pressure drop by the ratio and subtracting tobacco column pressure drop, it is possible to determine the encapsulated filter plug RTD necessary to maintain total cigarette pressure at a given level.

5. Summary

The next slide, "The Effect of Ventilation on Cigarette Performance" shows physical alterations to the smoking process.

1. A smaller than normal puff is taken.
2. Air flow around the burning cone decreases.
3. Flow rate upstream of the vents decreases.
4. Flow rate through the filter changes.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

To summarize, in general, deliveries of mainstream smoke decrease, deliveries of sidestream particulate phase are unchanged, sidestream CO increases, filtration efficiency increases and RTD decreases with increasing ventilation.

The graphs that follow summarize some important effects of ventilation.

1. Delivered tar, water and nicotine free decrease greater than 1:1 with increasing ventilation.
2. Delivered nicotine reduction is less than 1:1 with percent ventilation, up to about 60% ventilation.
3. Delivered CO reduction is greater than 1:1 with increasing ventilation.
4. CO_2/CO ratio increases with higher levels of ventilation.
5. Puff count increases with increasing percent ventilation.
6. Filtration efficiency increases with increasing percent ventilation.
7. Pressure drop is reduced by ventilation.
8. Subjective responses.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

THE EFFECTS OF AIR DILUTION

The end effect of ventilation is a reduction in delivered material to the smoker. This effect is achieved through two mechanisms.

I. SMOKE DILUTION

—A straight-forward reduction in per-puff smoke concentration via the introduction of air into the mainstream smoke.

II. REDUCTION OF SMOKE AEROSOL VELOCITY

—improved filtration efficiency of tobacco column and filter due to reduced aerosol velocity

—modified tobacco burn rate resulting in increased puff count, a change in tobacco combustion efficiency, increased diffusion of gas phase out of the tobacco column and a change in the vapor phase to particulate phase ratio.

The data presented in this section will help explain these phenomena. Their interaction, although complex, can be predicted from the empirical data.

Celanese

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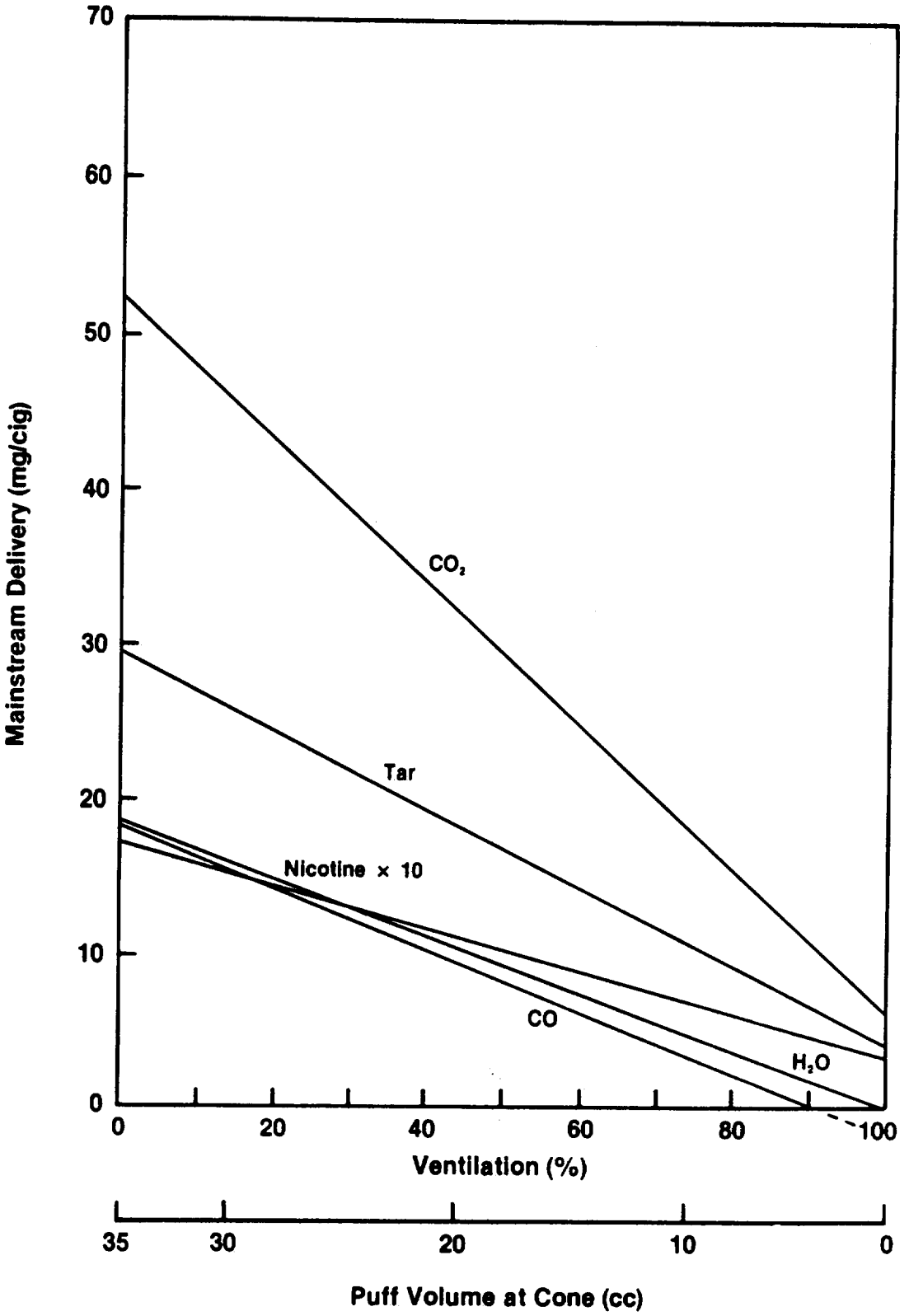
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

CALCULATED MAINSTREAM DELIVERY AS A FUNCTION OF DILUTION



Celanese

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TABLE I

MAINSTREAM PARTICULATE PHASE DATA
(including material captured on filters)

Description	Number of Puffs	Puff Volume at Coal (ml)	Particulate Matter (mg/cig)	Water (mg/cig)	Nicotine (mg/cig)	Tar (mg/cig)
35 ml puff volume:						
No dilution	8.7	35.0	46.35	15.28	1.69	29.38
33% dilution	8.8	23.5	32.47	8.68	1.44	27.35
48% dilution	9.8	18.2	20.89	4.12	1.06	15.71
83% dilution	10.6	6.0	11.58	2.06	0.55	8.97
17.5 ml puff volume:						
No dilution	9.6	17.5	29.35	6.71	1.19	21.45
33% dilution	10.3	11.7	18.55	4.65	0.89	13.01
50 ml puff volume:						
No dilution	7.4	50	55.31	18.97	2.07	34.27
33% dilution	8.3	33.5	45.7	14.15	1.79	29.76

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TABLE II

MAINSTREAM VAPOR PHASE DATA

Description	Number of Puffs	Puff Volume at Coal (ml)	CO (mg/cig)	CO_2 (mg/cig)	Water (mg/cig)	Nicotine (mg/cig)
35 ml puff volume:						
No dilution	8.7	35	18.6	52.2	4.17	.01
33% dilution	8.8	23.5	12.9	40.3	2.40	.01
48% dilution	9.8	18.2	6.6	27.4	2.88	.01
83% dilution	10.6	6.0	2.4	14.7	3.23	.00
17.5 ml puff volume:						
No dilution	9.6	17.5	9.3	32.4	2.21	.00
33% dilution	10.3	11.7	5.0	22.2	1.48	.00
50 ml puff volume:						
No dilution	7.4	50.0	20.4	56.9	5.98	.04
33% dilution	8.3	33.5	17.0	51.3	4.28	.03

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TABLE III

SIDESTREAM PARTICULATE PHASE DATA

Description	Number of Puffs	Puff Volume at Coal (ml)	Particulate Matter (mg/cig)	Water (mg/cig)	Nicotine (mg/cig)	Tar (mg/cig)
35 ml puff volume:						
No dilution	8.7	35	19.72	1.19	.97	17.55
33% dilution	8.8	23.5	21.11	1.25	1.07	18.79
48% dilution	9.8	18.2	21.08	1.00	1.12	18.96
83% dilution	10.6	6.0	21.09	0.89	1.01	19.19
Free burn	0.0	0.0	23.40	0.67	1.32	21.41
17.5 ml puff volume:						
No dilution	9.6	17.5	22.61	1.17	1.13	20.31
33% dilution	10.3	11.7	20.30	1.01	0.98	18.31
50 ml puff volume:						
No dilution	7.4	50	21.27	1.40	1.23	18.64
33% dilution	8.3	33.5	21.82	0.93	1.06	19.83

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TABLE IV

SIDESTREAM VAPOR PHASE DATA

Description	Number of Puffs	Puff Volume at Coal (ml)	CO (mg/cig)	CO_2 (mg/cig)	Water (mg/cig)	Nicotine (mg/cig)
35 ml puff volume:						
No dilution	8.7	35	49.6	421.7	277.4	4.97
33% dilution	8.8	23.5	49.3	430.1	272.2	5.66
48% dilution	9.8	18.2	58.4	520.4	256.8	5.24
83% dilution	10.6	6.0	56.3	536.4	274.9	5.89
Free burn	0.0	0.0	58.1	571.0	281.3	6.38
17.5 ml puff volume:						
No dilution	9.6	17.5	63.0	546.5	238.9	5.43
33% dilution	10.3	11.7	62.2	598.0	212.4	6.05
50 ml puff volume:						
No dilution	7.4	50	56.4	438.7	195.0	4.89
33% dilution	8.3	33.5	56.7	448.4	233.6	5.15

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TABLE V

TOTAL DELIVERY, MAINSTREAM AND SIDESTREAM

Description	No. of Puffs	Puff Vol. at Coal (ml)	Tar (mg/cig)	Water (mg/cig)	Nicotine (mg/cig)	CO (mg/cig)	CO_2 (mg/cig)
35 ml puff volume:							
No dilution	8.7	35	46.9	298.0	7.64	68.2	473.9
33% dilution	8.8	23.5	41.1	284.5	8.18	62.2	470.4
48% dilution	9.8	18.2	34.7	264.8	7.43	65.0	547.8
83% dilution	10.6	6.0	28.2	280.7	7.45	58.7	551.1
Free burn	0.0	0.0	23.40	282.0	7.70	58.1	571.0
17.5 ml puff volume:							
No dilution	9.6	17.5	41.8	249.0	7.75	72.3	578.9
33% dilution	10.3	11.7	31.3	219.5	7.92	67.2	620.2
50 ml puff volume:							
No dilution	7.4	50	52.9	221.4	8.23	76.8	495.6
33% dilution	8.3	33.5	49.6	253.0	8.03	73.7	499.7

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TABLE VI

MAINSTREAM DELIVERIES PER GRAM OF TOBACCO BURNT DURING PUFFING (mg/gm)

Description	Puff Volume at Coal (ml)	Tar	Water	Nicotine	CO	CO_2
35 ml puff volume:						
No dilution	35	239	158	13.8	151	424
33% dilution	23.5	251	124	16.3	145	453
48% dilution	18.2	212	95	14.4	89	370
83% dilution	6	236	139	14.5	63	387
17.5 ml puff volume:						
No dilution	17.5	298	124	16.5	129	450
33% dilution	11.7	236	111	16.2	91	404
50 ml puff volume:						
No dilution	50	205	149	12.6	122	341
33% dilution	33.5	250	155	15.3	143	431
Average		241	137	14.7	124	411
S.D.		25	23	1.3	32	36
C.V.		10.4%	16.5%	8.9%	25.6%	8.7%

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TABLE VII

SIDESTREAM DELIVERIES PER GRAM OF TOBACCO BURNT DURING RESTING (mg/gm)

Description	Puff Volume at Coal (ml)	Tar	Water	Nicotine	CO	CO_2
35 ml puff volume:						
No dilution	35	31.6	501	10.7	89.2	758
33% dilution	23.5	31.8	464	11.4	83.6	729
48% dilution	18.2	31.3	426	10.5	96.5	860
83% dilution	6	29.9	430	10.8	87.8	837
17.5 ml puff volume:						
No dilution	17.5	33.5	396	10.8	104	900
33% dilution	11.7	29.3	342	12.8	100	958
50 ml puff volume:						
No dilution	50	36.4	384	12.0	110	857
33% dilution	33.5	35.4	418	11.1	101	801
Free burn	0	35.5	428	11.7	88.2	866
Average		32.5	436	11.2	94.4	826
S.D.		2.3	52	.7	8.3	71
C.V.		7.2%	12.0%	6.3%	8.8%	8.6%

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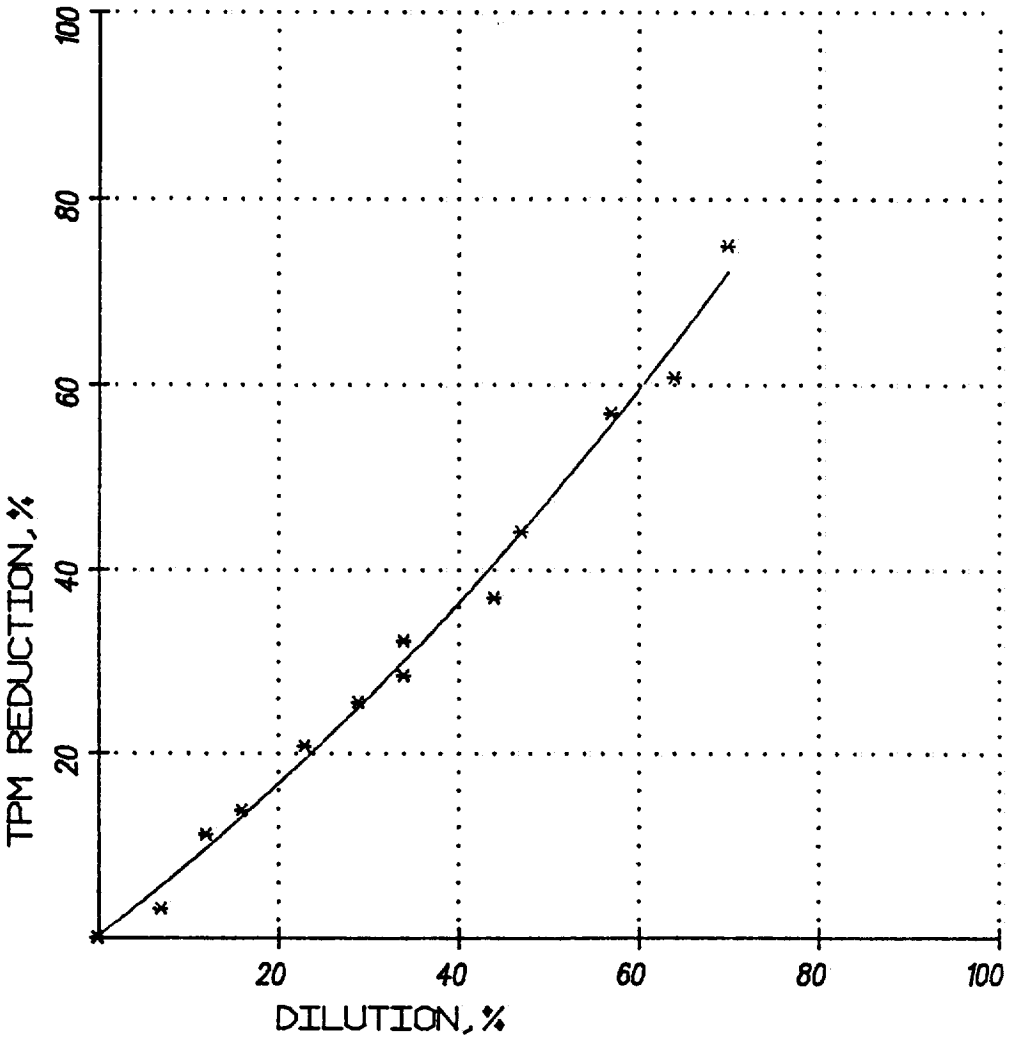
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TPM REDUCTION VS. DILUTION



21MM, 25MM, AND 31MM FILTER LENGTHS
3.4/46K TOW #10 CORR. COEF.= 0.99

7/29/82

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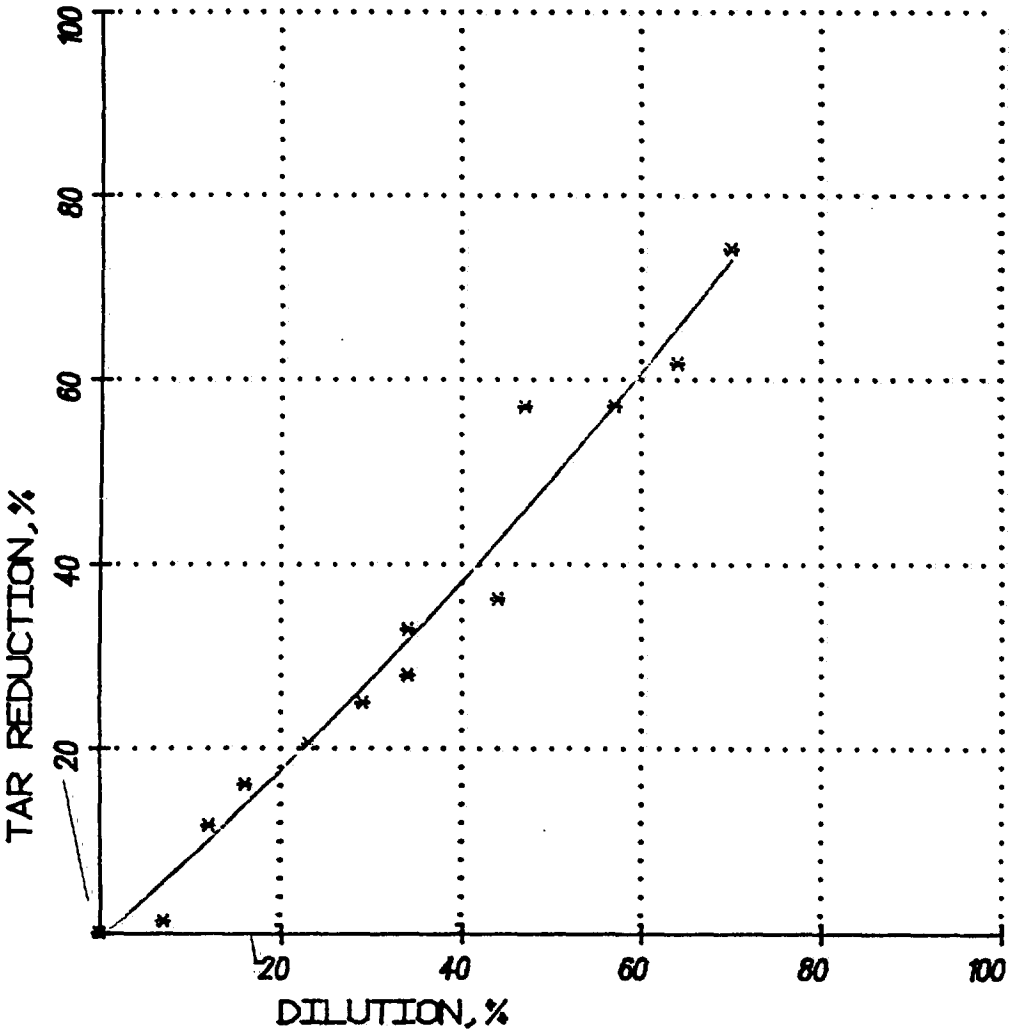
TPM.CH

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TAR REDUCTION VS. DILUTION



21MM, 25MM, AND 31MM FILTER LENGTHS
3.4/46K TOW #10 CORR. COEF.= 0.99

2025445445

7/16/82

TAR.CHT #1

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF VENTILATION ON TAR DELIVERY

VENTILATION, %	TAR DELIVERY, MG/CIG	DECREASE IN TAR DELIVERY, %
0	15.0	0.0
10	14.4	4.0
20	12.8	14.7
30	11.3	24.7
40	10.0	33.3
50	8.9	40.7
60	7.3	51.3
70	5.0	66.7
80	2.5	83.3
90	0.4	97.3

Eastman

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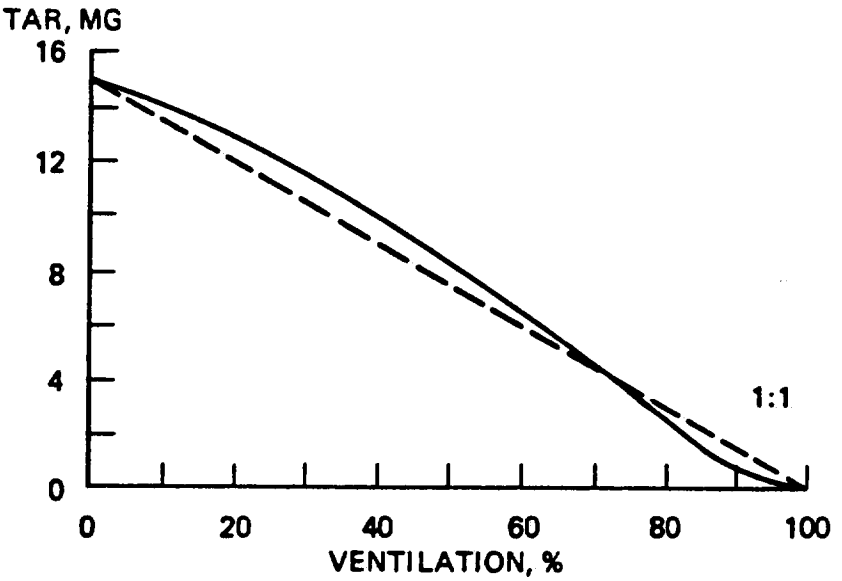
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF VENTILATION ON TAR DELIVERY

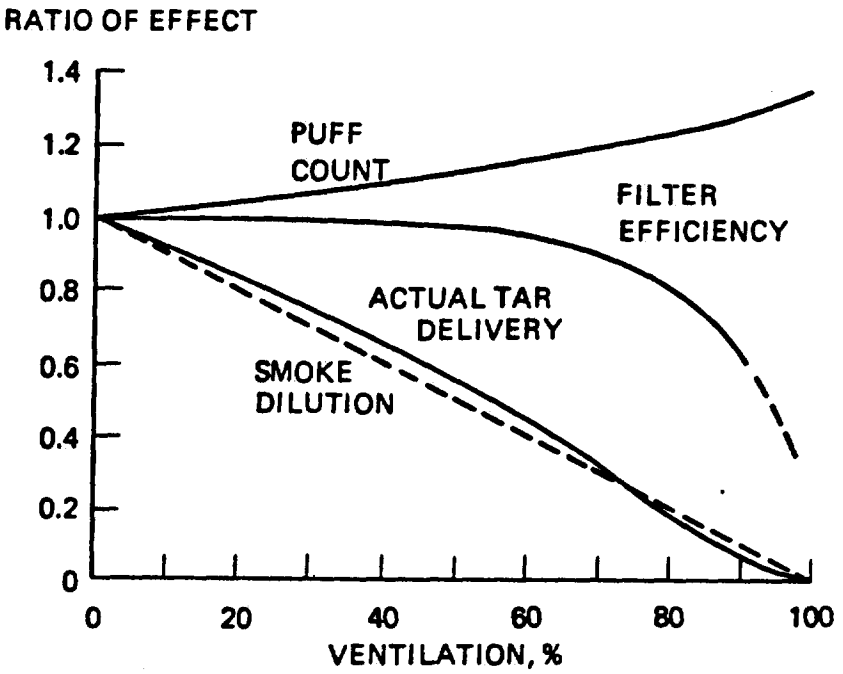


Eastman

2025445447

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF VENTILATION ON TAR DELIVERY



Eastman

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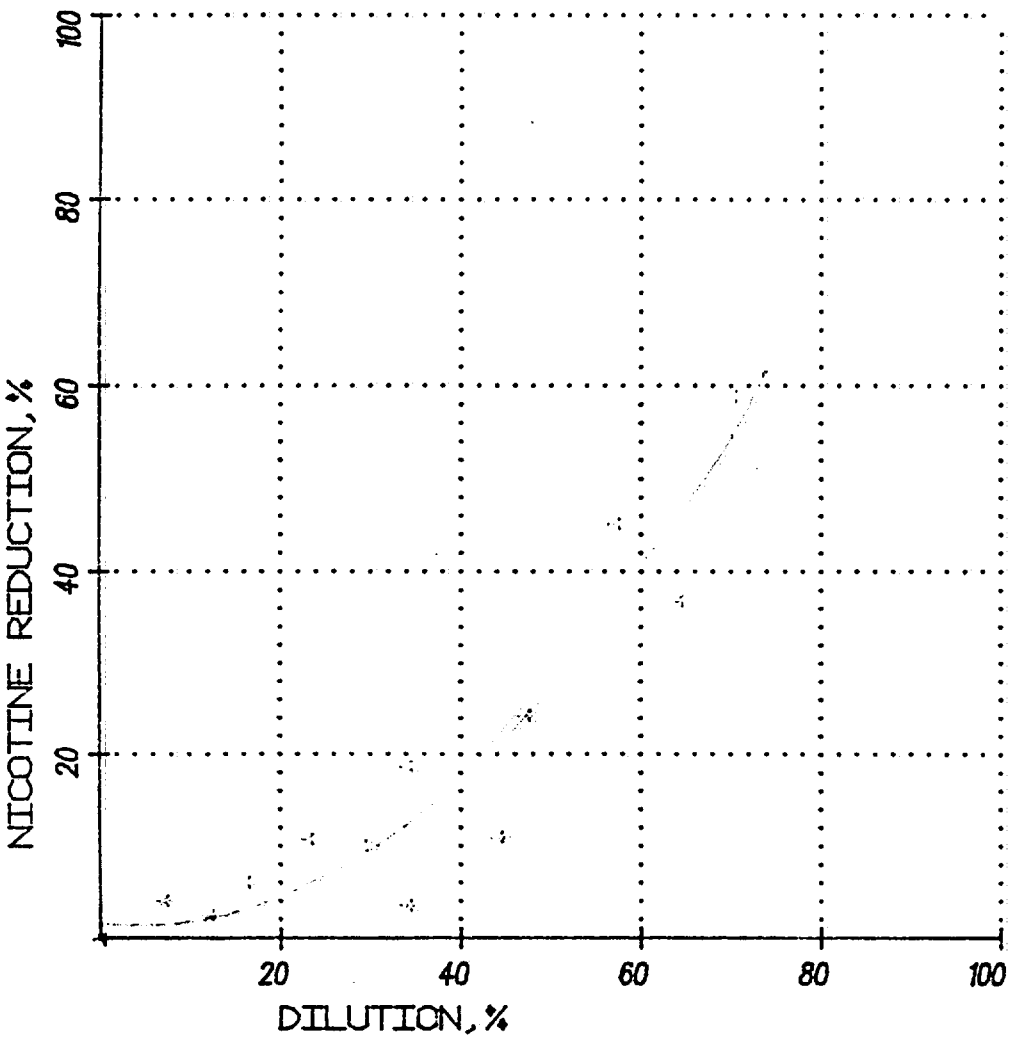
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

NICOTINE REDUCTION VS. DILUTION



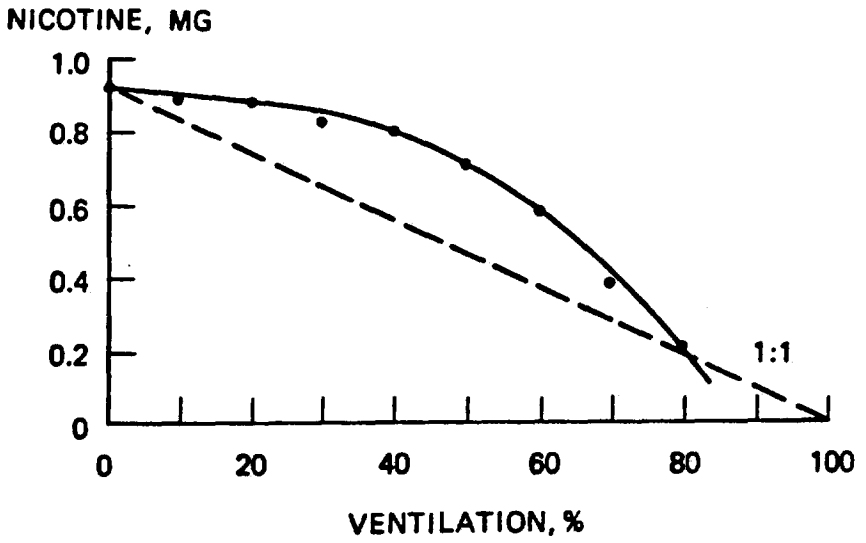
21MM, 25MM, AND 31MM FILTER LENGTHS
3.4/46K TOW #10 CORR. COEF.= 0.90

2025445449

NIC.CHT #5 1

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF VENTILATION ON DELIVERY OF NICOTINE



Eastman

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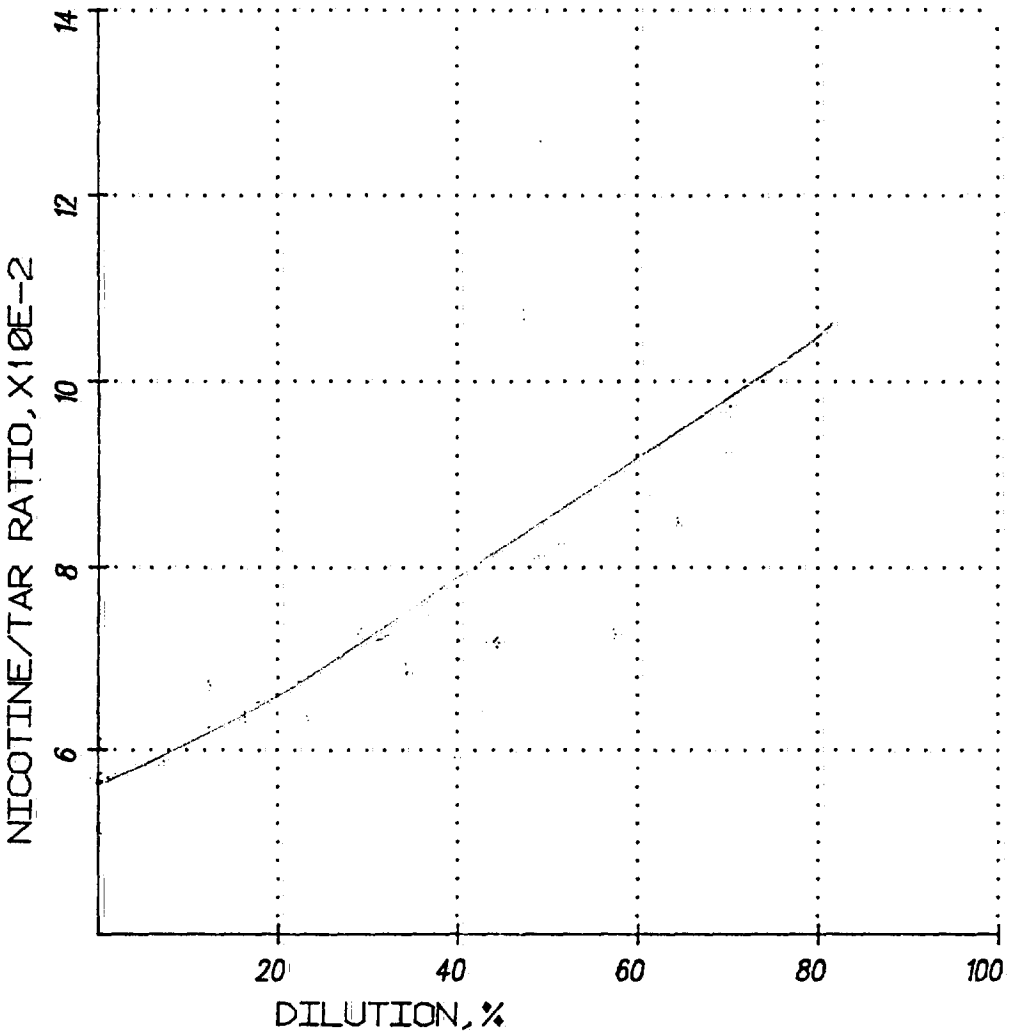
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

NICOTINE/TAR RATIO VS. DILUTION



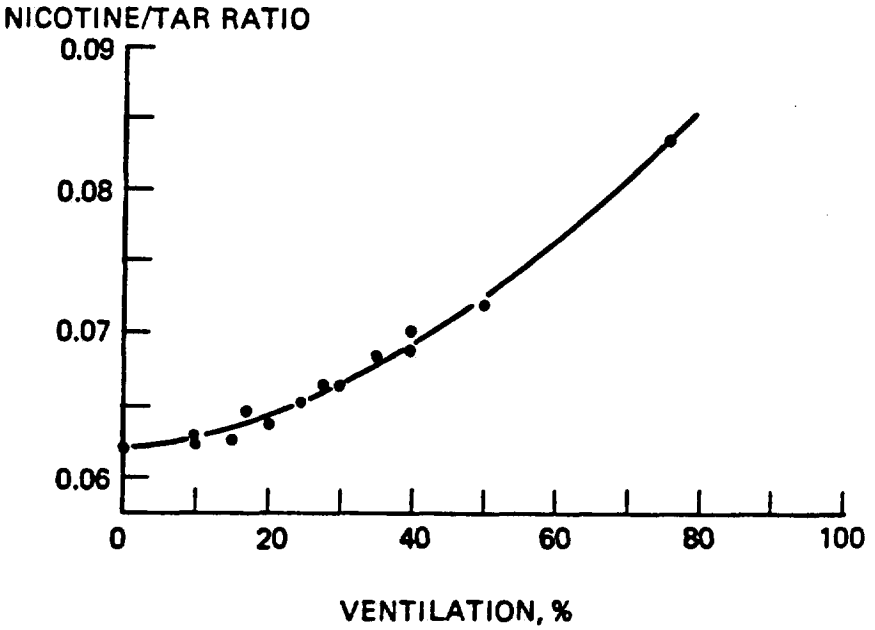
21MM, 25MM, AND 31MM FILTER LENGTHS
3.4/46K TOW #10 CORR. COEF.= 0.81

2025445451

NT.CHT #5 1

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF VENTILATION ON NICOTINE TO TAR RATIO



Eastman

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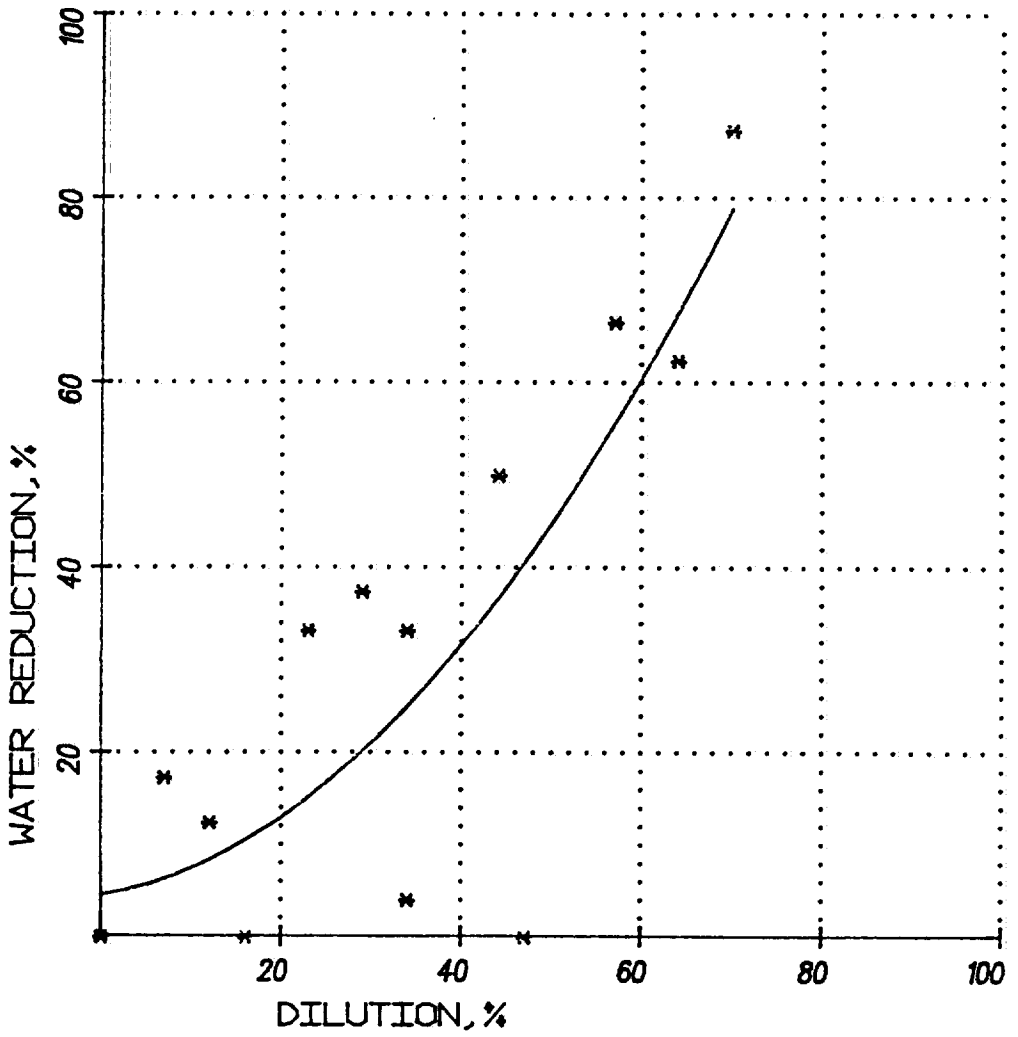
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

WATER REDUCTION VS. DILUTION



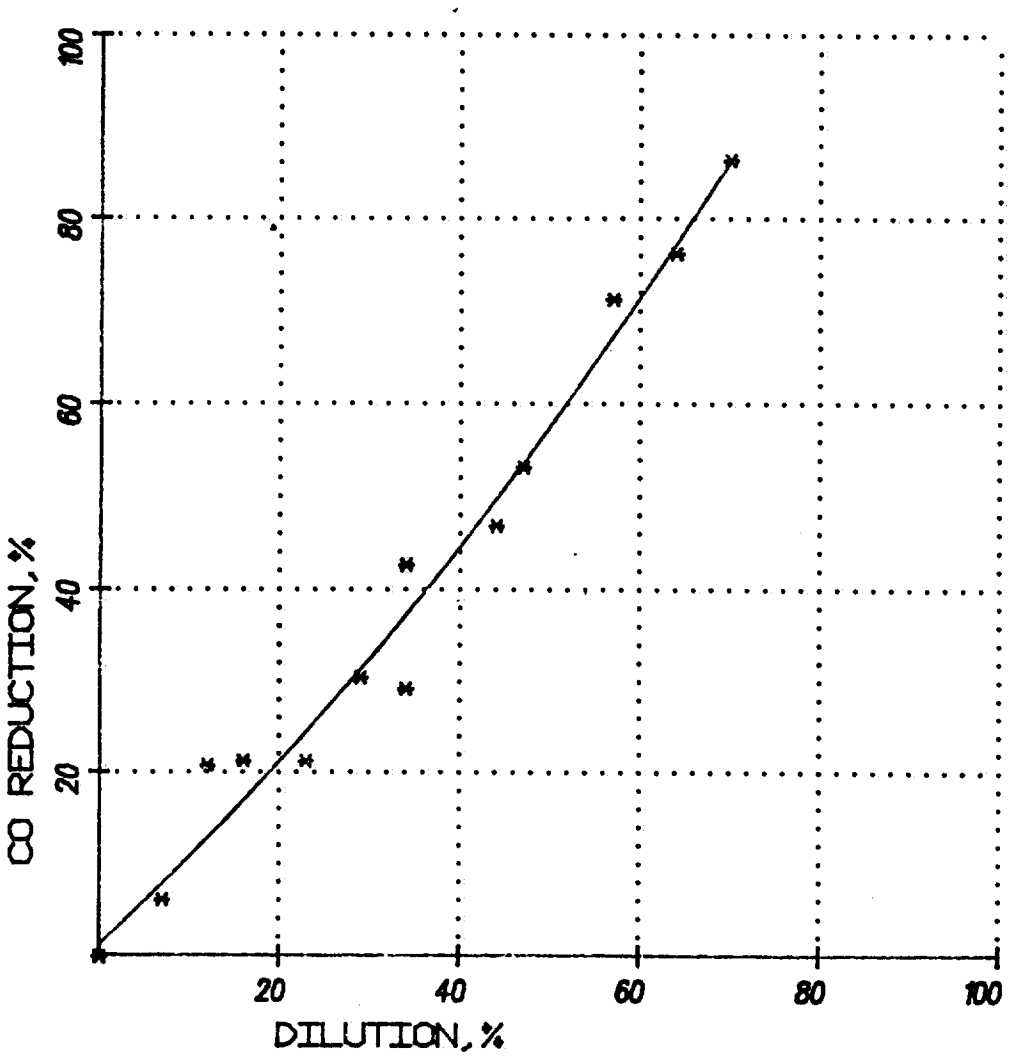
21MM, 25MM, AND 31MM FILTER LENGTHS
3.4/46K TOW #10 CORR. COEF.= 0.81

2025445453

WATER.CHT #5 1

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

CO REDUCTION VS. DILUTION



21MM, 25MM, AND 31MM FILTER LENGTHS
3.4/46K TOW #10 CORR. COEF.= 0.99

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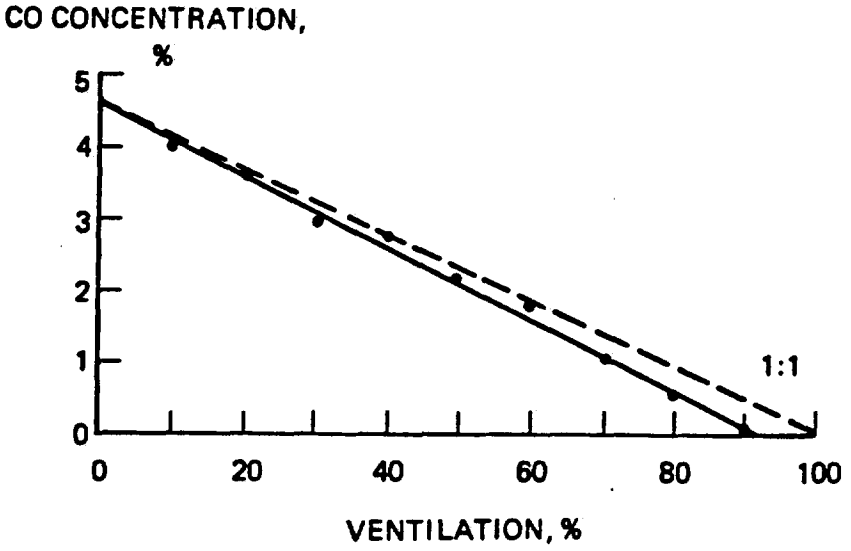
CO.CHT #5 1

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF VENTILATION ON DELIVERY OF CO



Fastman

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

REDUCTION IN CARBON MONOXIDE BY VENTILATION (PER PUFF BASIS)

PUFF NUMBER	CO CONTENT OF SMOKE, % NONVENTED	CO CONTENT OF SMOKE, % VENTED*	REDUCTION IN CO BY VENTS, %
SECOND	4.1	0.5	89
LAST	7.5	1.7	77
TOTAL	5.6	1.1	80

*VENTILATION = 76%

Eastman

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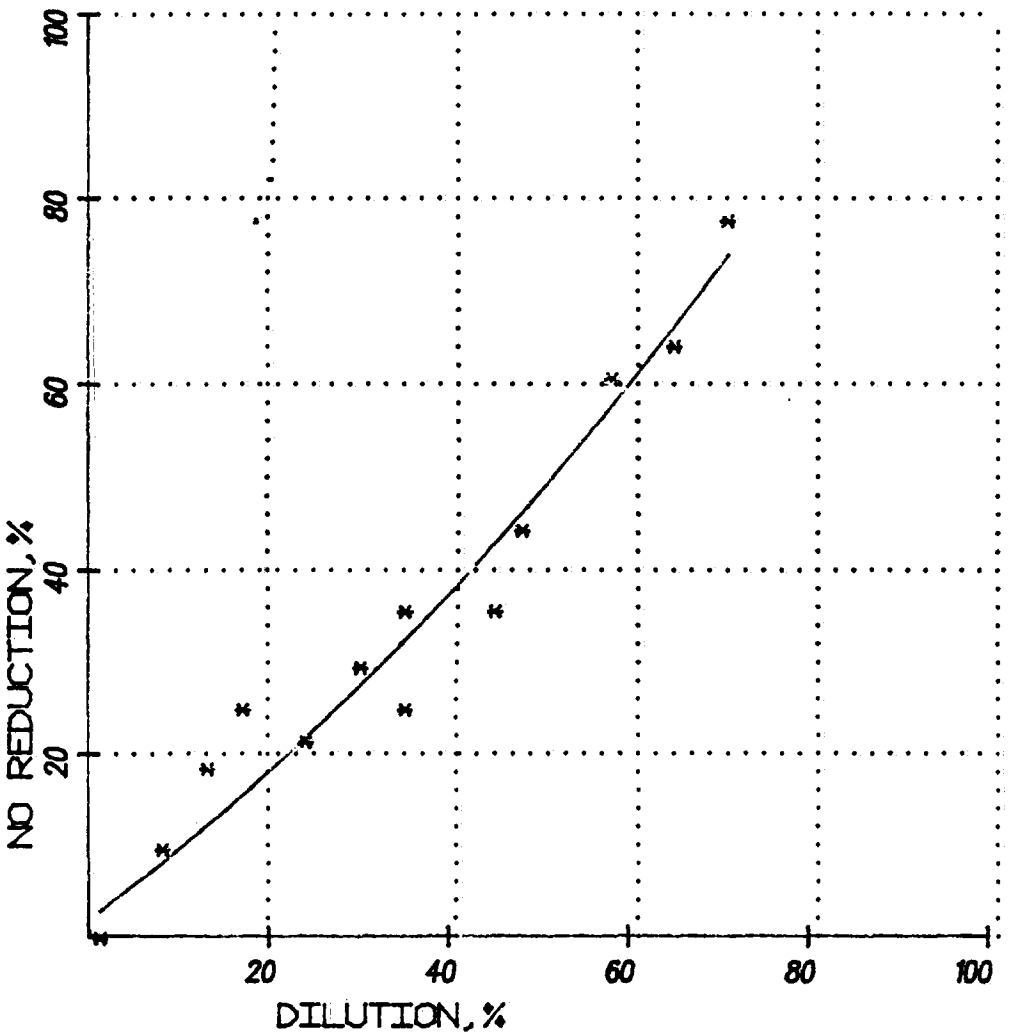
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

NO REDUCTION VS. DILUTION



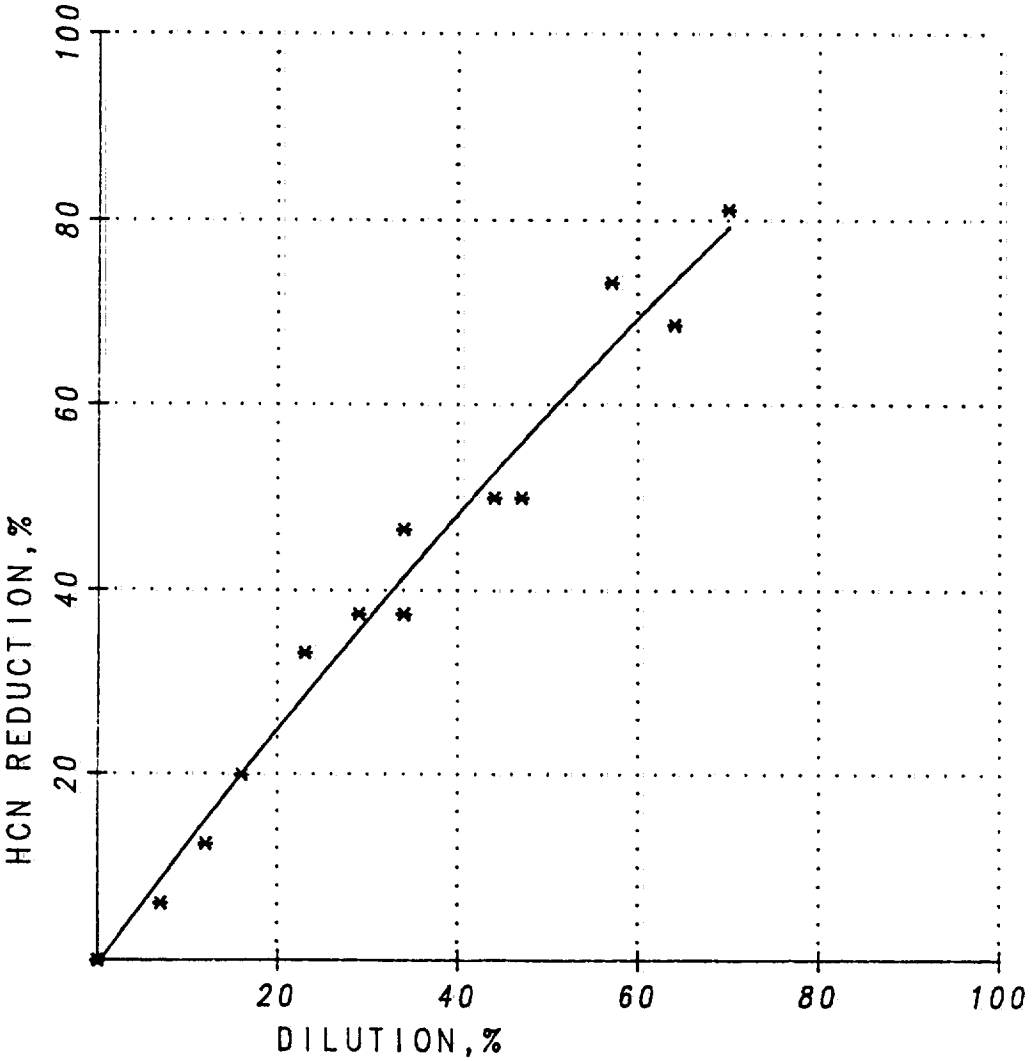
21MM, 25MM, AND 31MM FILTER LENGTHS
3.4/46K TOW #10 CORR. COEF.= 0.98

2025445457

NO.CHT #5 1

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

HCN REDUCTION VS. DILUTION



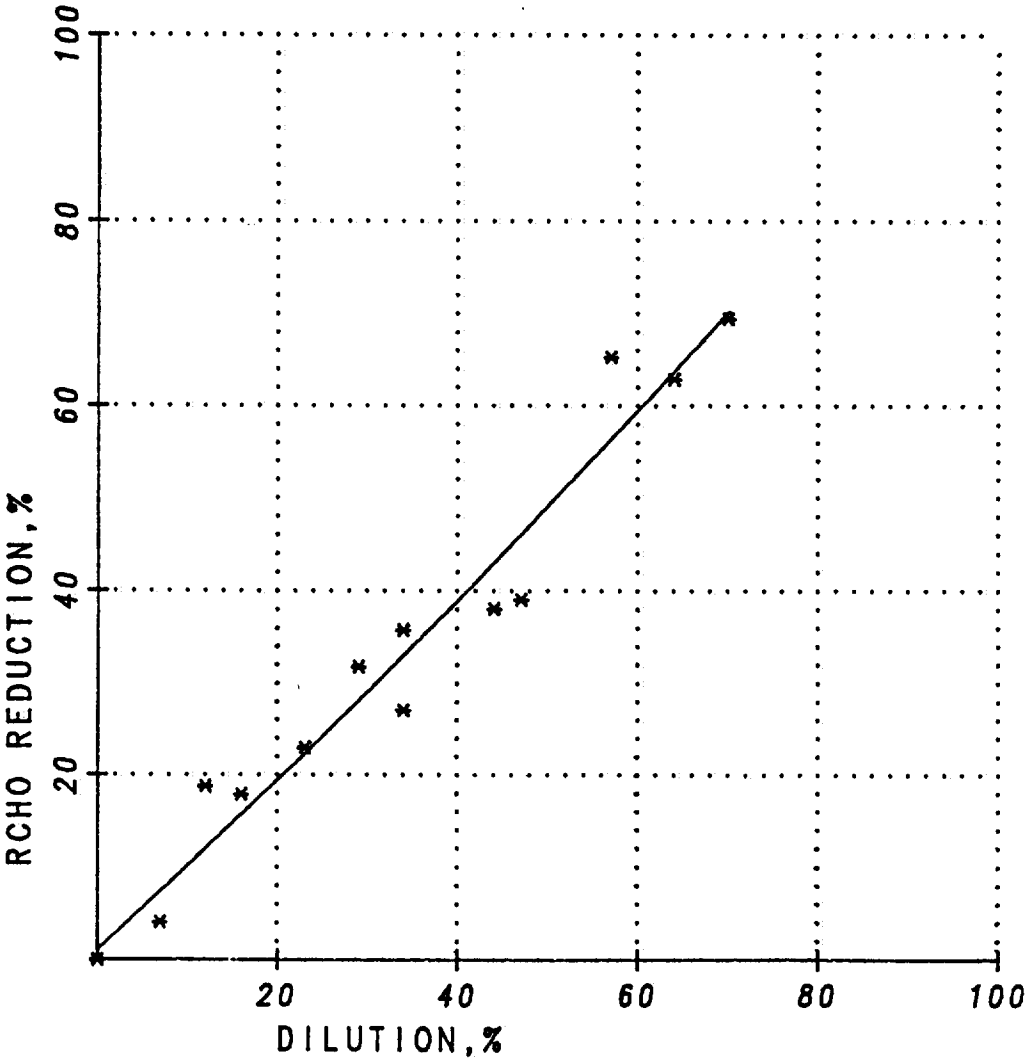
21MM, 25MM, AND 31MM FILTER LENGTHS
3.4/46K TOW #10 CORR. COEF.= 0.99

2025445458

HCN.CHT #5 1

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

RCHO REDUCTION VS. DILUTION



21MM, 25MM, AND 31MM FILTER LENGTHS
3.4/46K TOW #10 CORR. COEF.= 0.98

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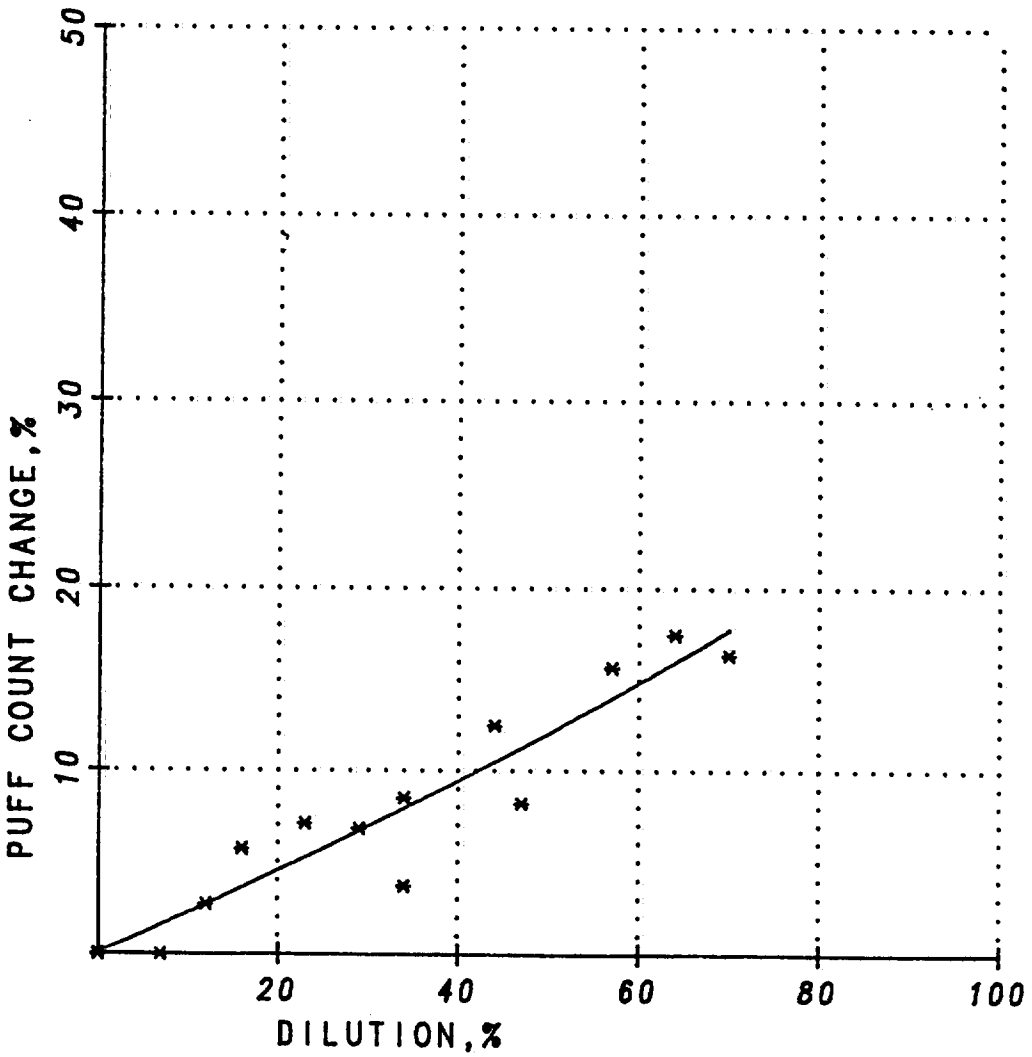
RCHO.CHT #5 1

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

PUFF COUNT CHANGE VS. DILUTION



21MM, 25MM, AND 31MM FILTER LENGTHS
3.4/46K TOW #10 CORR. COEF.= 0.95

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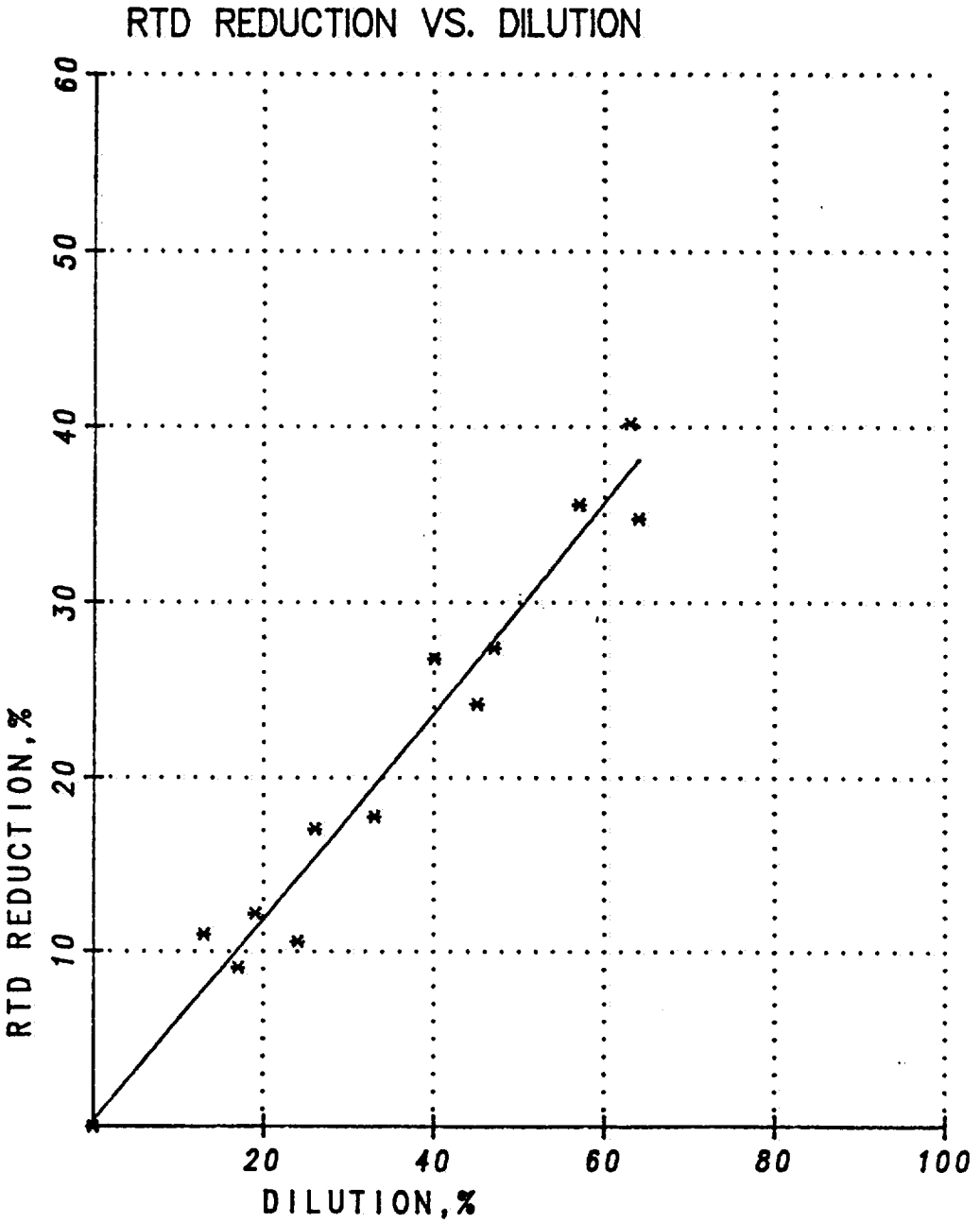
PUFF.CHT #5 1

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000



21MM, 25MM, AND 31MM FILTER LENGTHS
2.5/51K TOW #10 CORR. COEF.= 0.99

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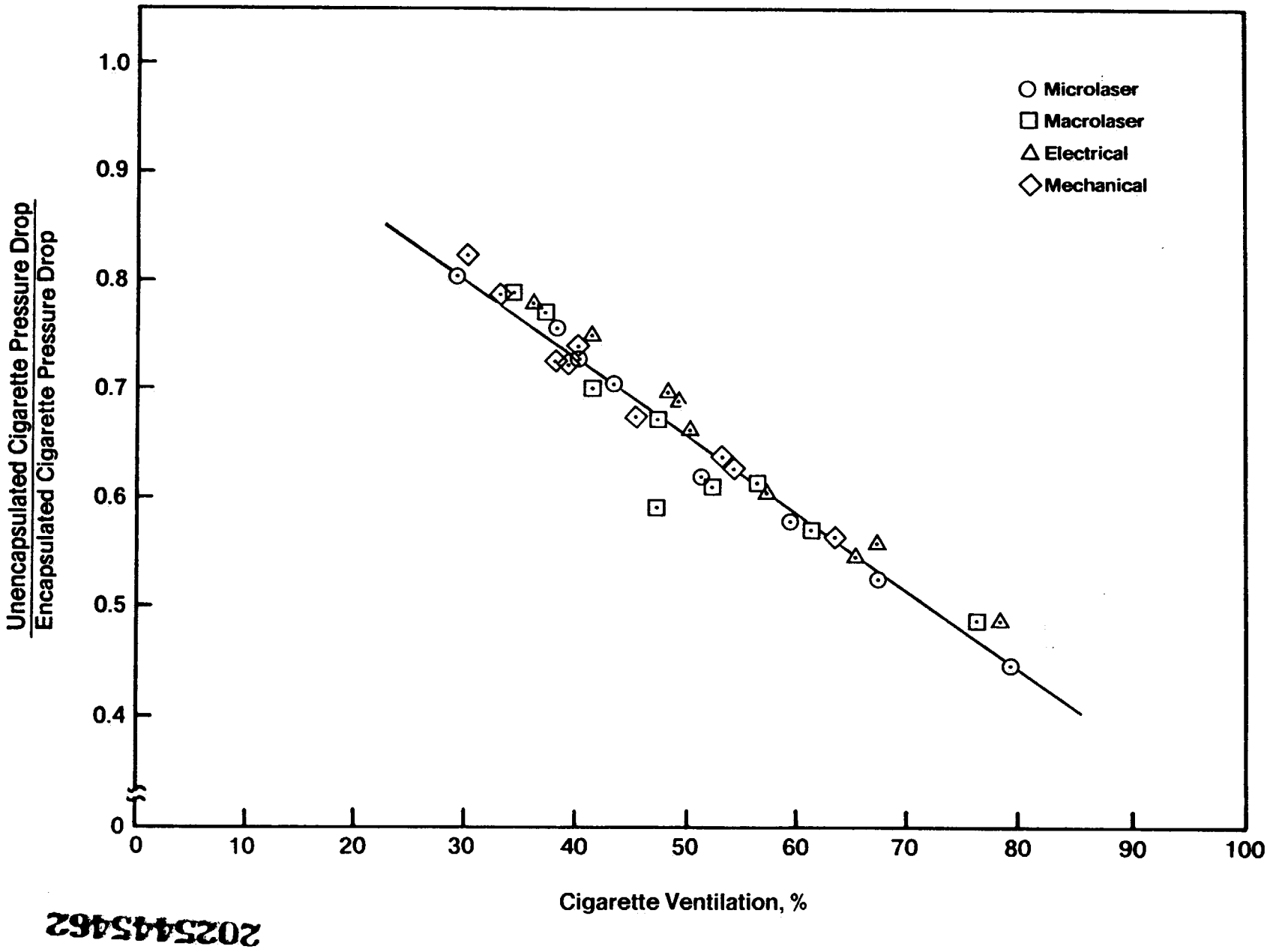
RTD.CHT #4 1

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF VENTILATION ON CIGARETTE PRESSURE DROP



Celanese

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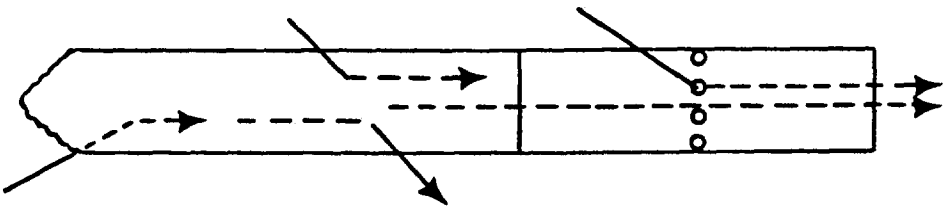
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF VENTILATION ON CIGARETTE PERFORMANCE



1. A SMALLER THAN NORMAL PUFF IS TAKEN.
2. AIR FLOW AROUND THE BURNING CONE DECREASES.
3. FLOW RATE UPSTREAM OF THE VENTS DECREASES.
4. FLOW RATE AND FLOW PATTERN THROUGH THE FILTER CHANGE.

Eastman

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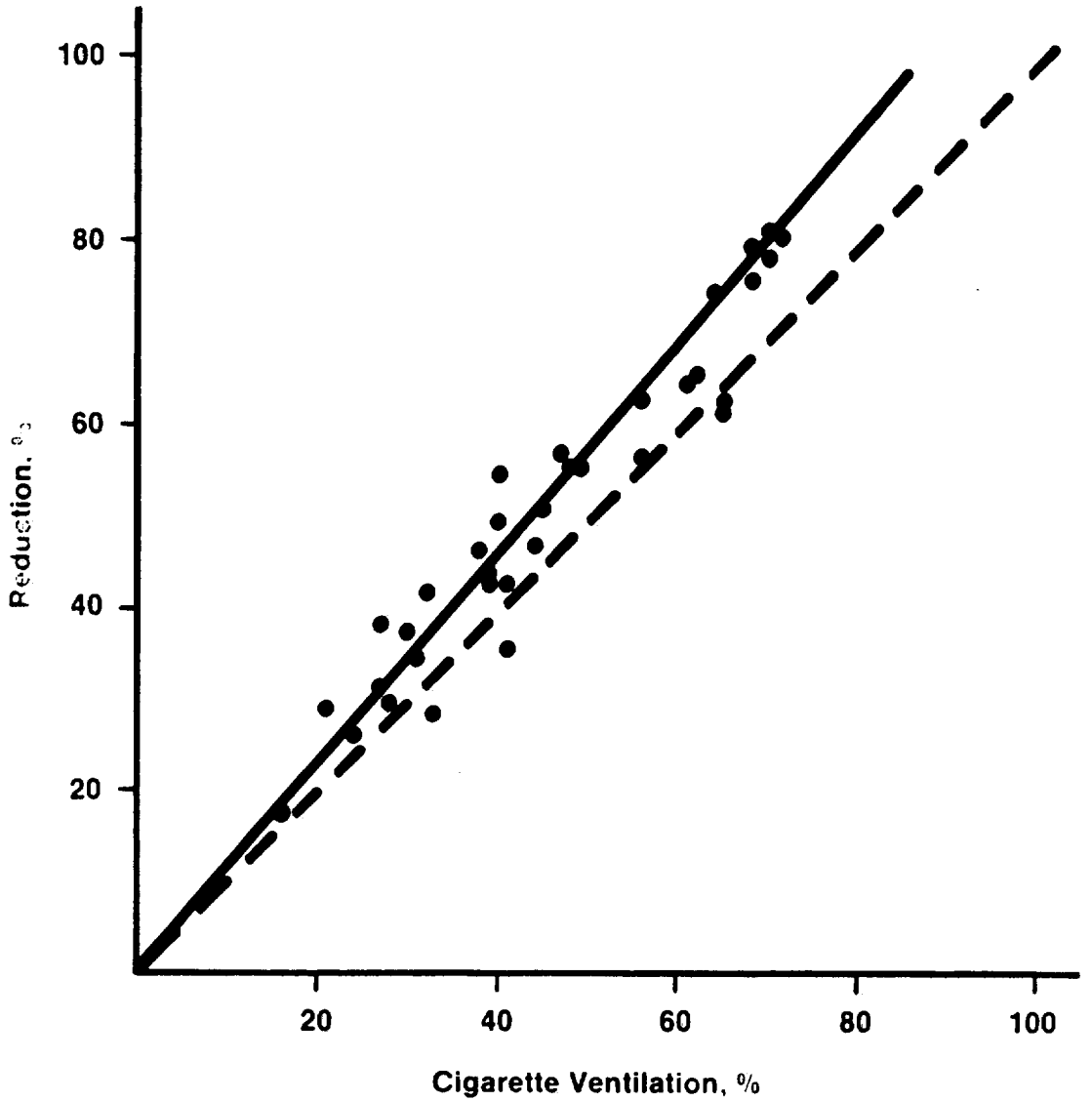
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

DELIVERED TAR (WNF) REDUCTION VS CIGARETTE VENTILATION



Celanese

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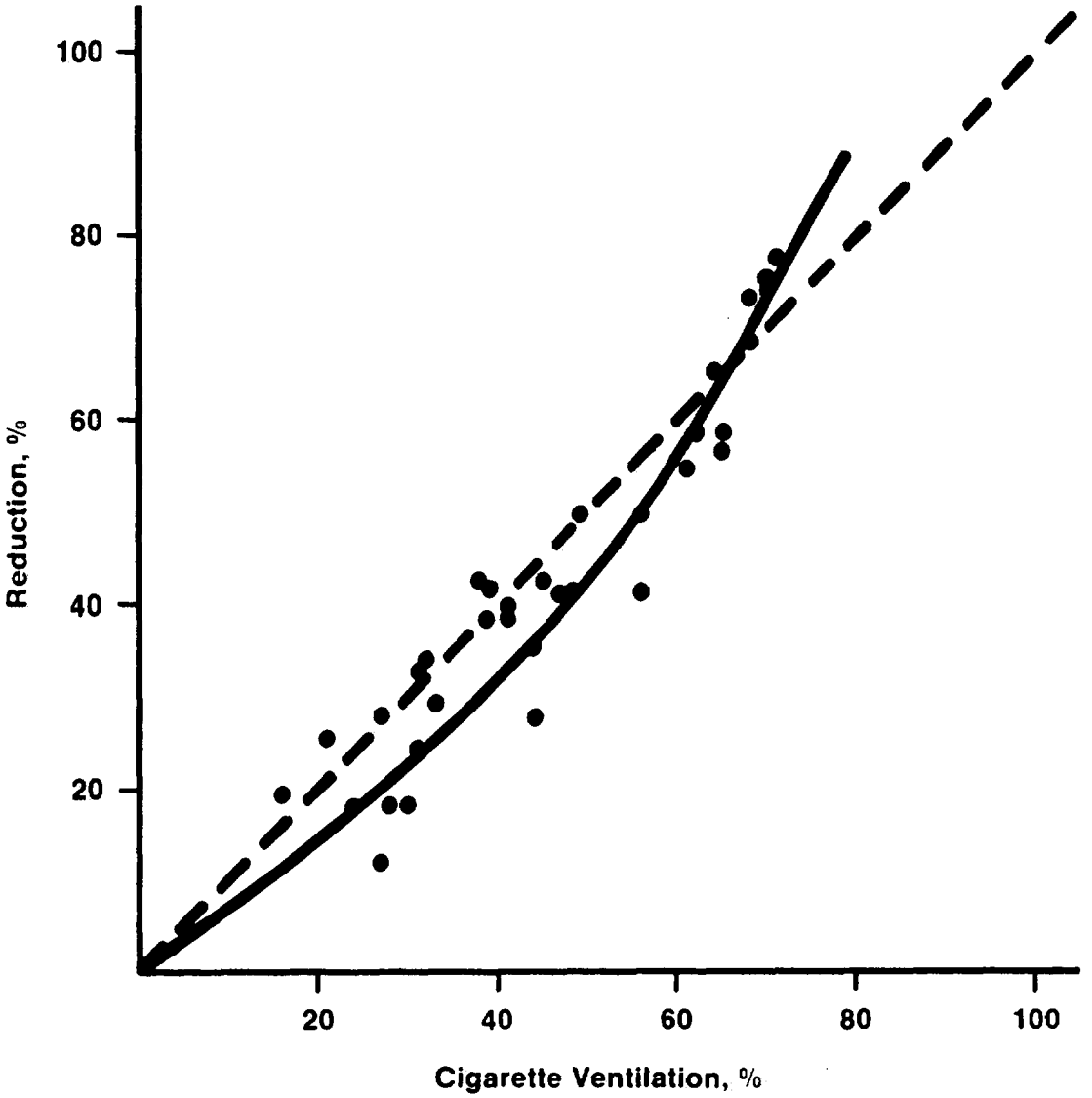
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

DELIVERED NICOTINE REDUCTION
VS
CIGARETTE VENTILATION



Celanese

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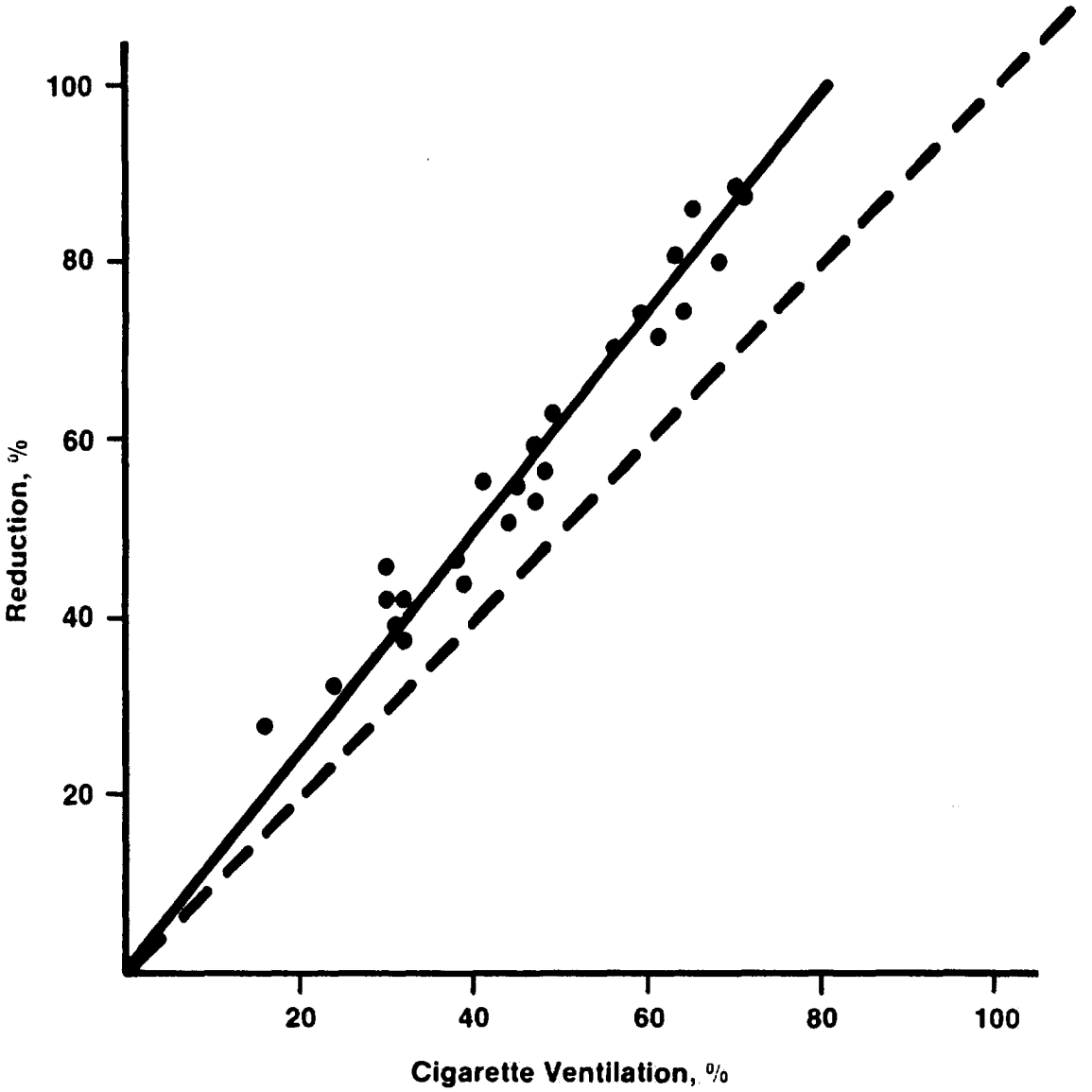
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

DELIVERED CARBON MONOXIDE REDUCTION
VS
CIGARETTE VENTILATION



Celanese

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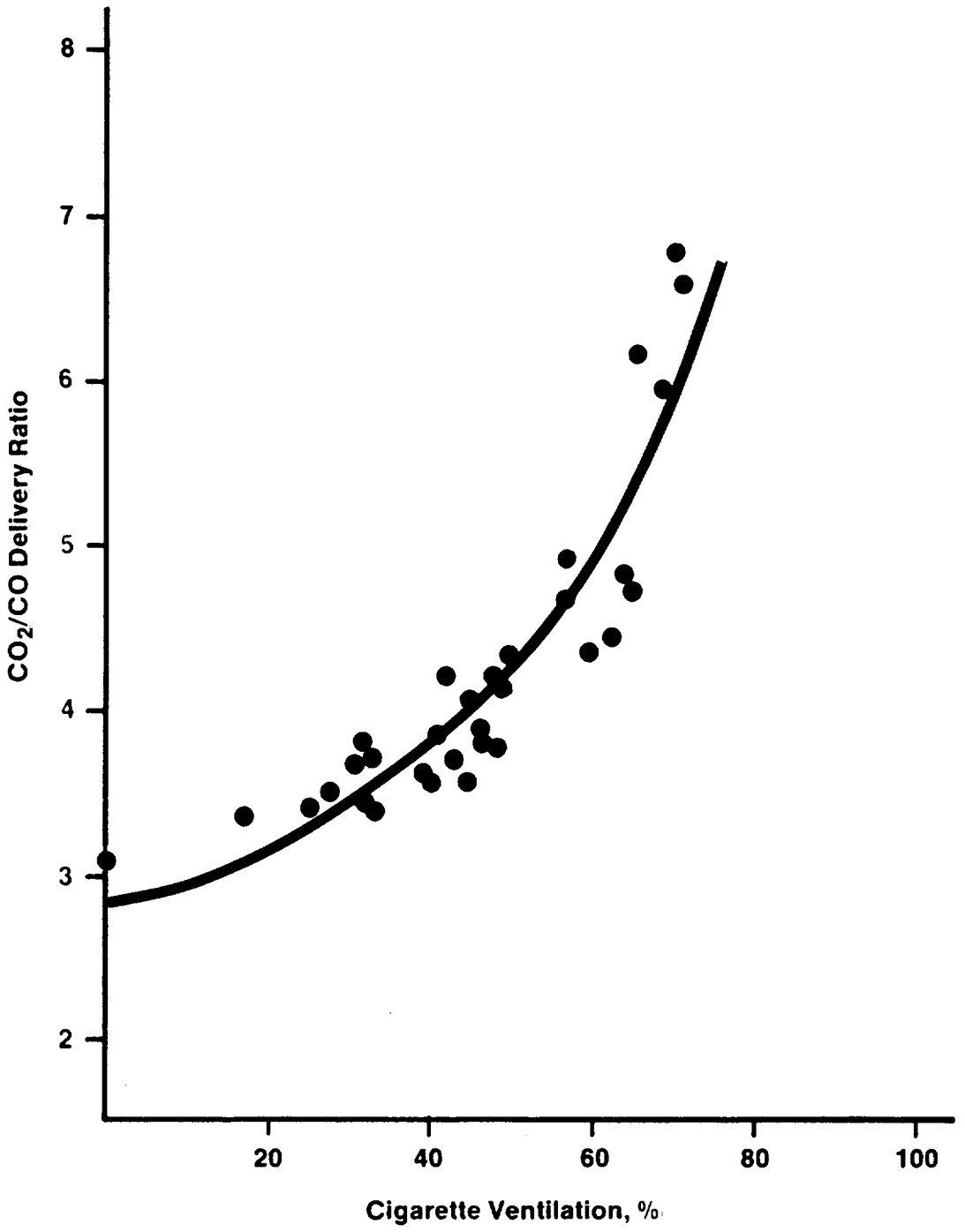
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

CO_2/CO DELIVERY RATIO VS CIGARETTE VENTILATION



Celanese

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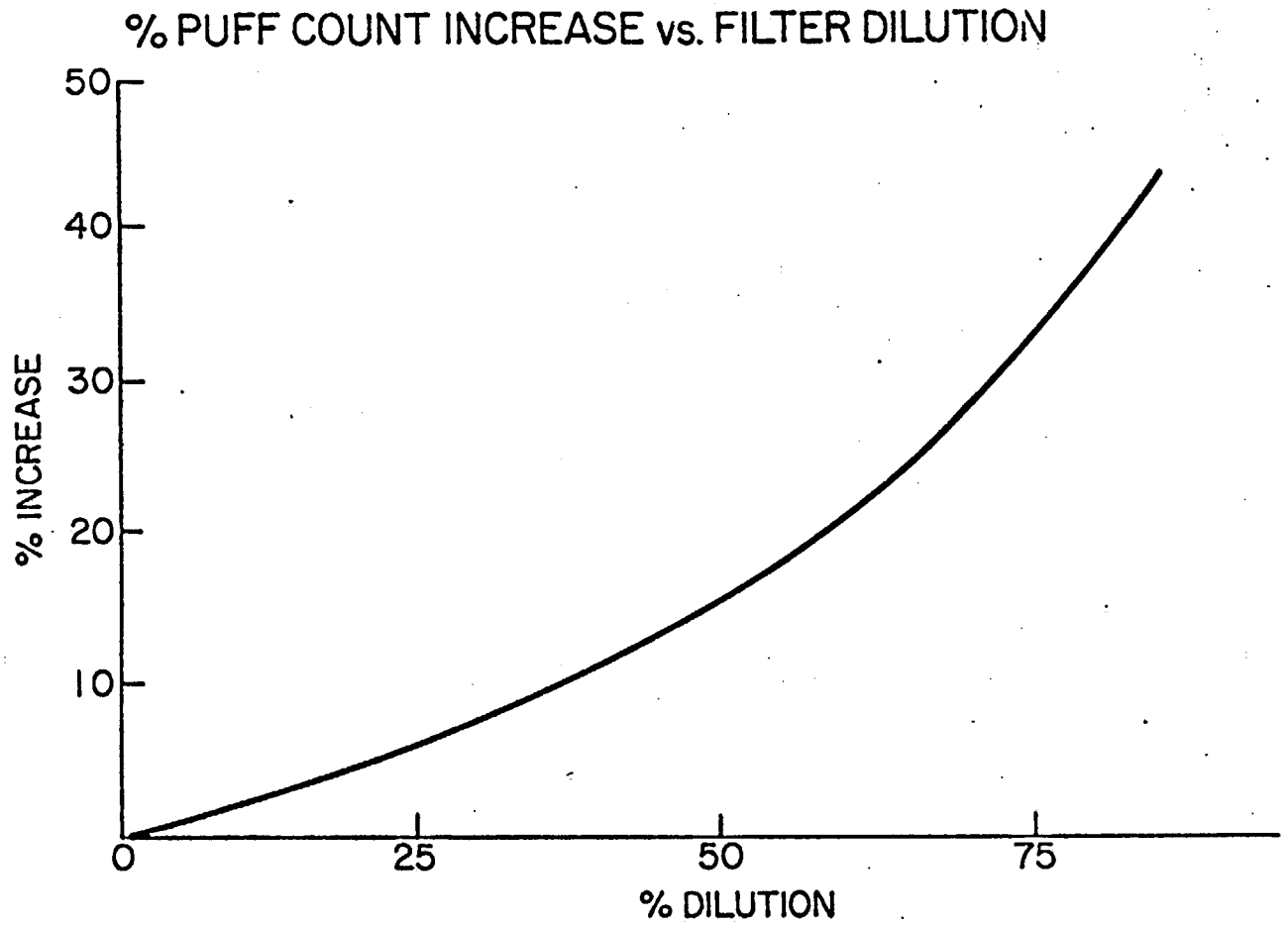
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000



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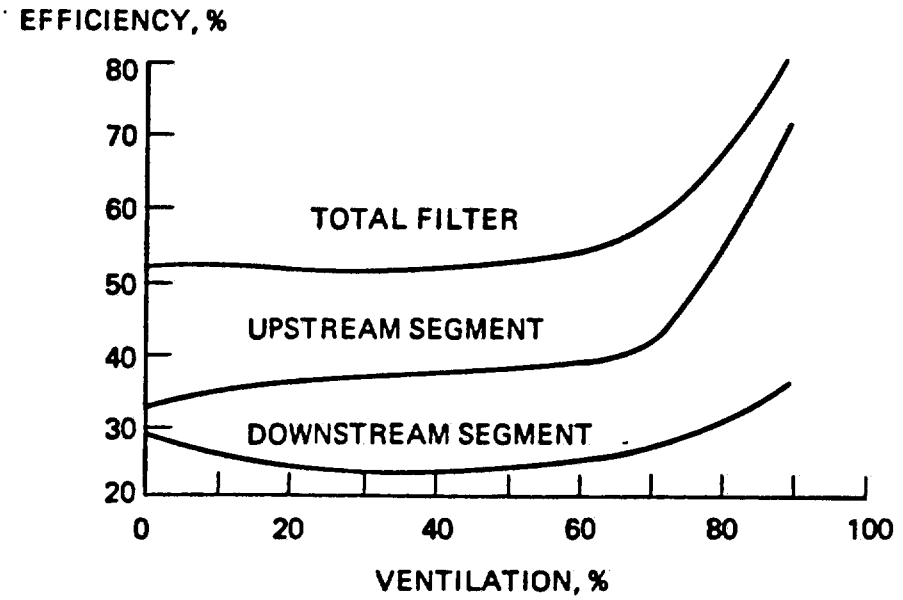
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF VENTILATION ON FILTRATION EFFICIENCY



Eastman

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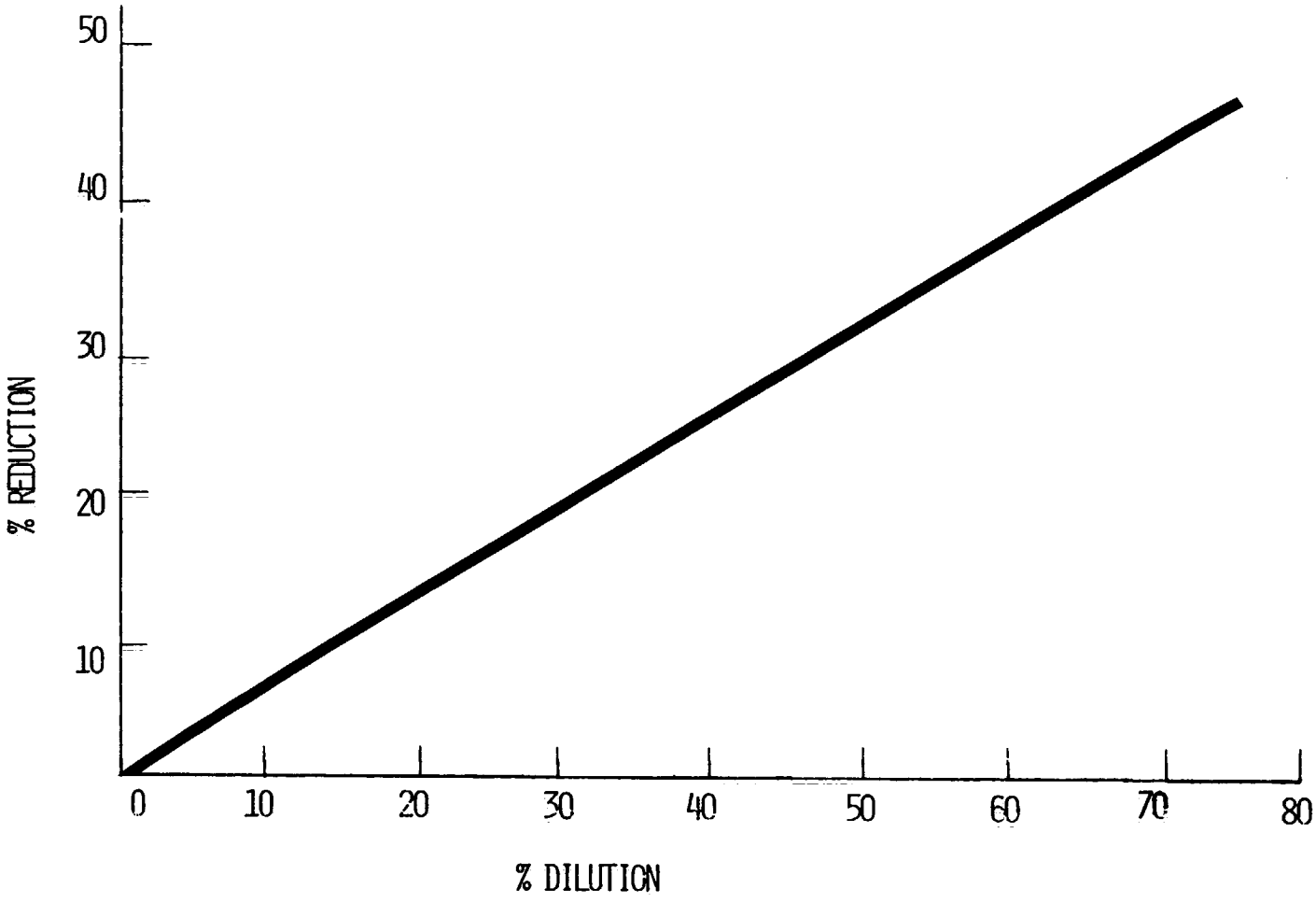
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

% PRESSURE DROP REDUCTION vs FILTER DILUTION



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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

SUBJECTIVE RESPONSES TO VENTILATED CIGARETTES

If a person normally smokes a ventilated brand:

- Increased finger staining
- Puff-volume increase
- Burn-out frequency increase
- Loose tobacco and coal fall-out
- Reduced impact/taste
- Flavor impact.

non-vent

- change draw - ext.
- Harder to light
- Air cooling antagnie
- Mouth drying
- Reduced impact

Celanese

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

G. Types of Ventilation

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

G. TYPES OF VENTILATION

Over the years, a number of ways have been tried to ventilate cigarettes. Some of these methods have seen only a very limited application on a commercial scale. Other have been refined into standards of the industry. Another group of methods has enjoyed widespread popularity at one time, only to be phased out for a more efficient means. Several more, while technologically feasible, have not been able to make it past the R&D and test market stage of the corporations who choose whether or not to pursue a particular ventilation method.

Basically, there are two types of ventilating methods: the first type is Off Line, and the other is On Line. On Line ventilation is done directly on the maker. It may perforate the plug only, tipping paper only, or the complete filter. Whatever the means, On Line perforation is done at some point on the maker. Most of these methods can be added as direct modifications to existing makers. The other type of ventilation, Off Line, involves an assembling at the makers of some component(s) that have been ventilated at another point in the process. This need not be done in the same factory. For example, all of the major cigarette company paper suppliers offer pre-perforated paper.

Each of the different types of ventilation will be discussed in varying degrees of detail. The relative advantages and disadvantages of each are covered. The economics of each method are not discussed, as they are beyond the scope of this seminar. Which method is best depends on a number of criterion, although some consistently stand-out above the others. Each operation must evaluate their own needs. Every effort has been made to make this listing as complete as possible. Although some of these methods have little to recommend them, they

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

are mentioned to expose you to the entire spectrum of choices. If something doesn't work, we want to show you why it doesn't work. It is far better to utilize the experience gained by us and others over the years than have to go through unnecessary rediscovery projects.

1. Cigarette Paper

There are essentially three types of ventilated cigarette paper that have been used. The first, and by far the most widely used, is porous cigarette paper. The second is perforated cigarette paper, which has seen limited use. The third type is programmed cigarette paper, a novel idea that never quite made it.

The concept of cigarette paper ventilation is used almost exclusively as a complement to tip dilution. It is entirely possible to ventilate the cigarette strictly through the rod, or cigarette paper, but the big disadvantage with this is the dynamic nature of the dilution level. Obviously, as the rod is consumed, the degree of ventilation changes. The last few puffs have much less dilution than the first puffs. On a non-ventilated cigarette, the later puffs naturally have a higher delivery level than the first puffs. With rod ventilation, this phenomenom is compounded, making the difference even more perceptible. The second problem with rod ventilation is the fairly limited range of delivery reductions that can be achieved without incorporating other ventilations too. These limits were discussed in detail in the PAPER section, but to reiterate, about a 100 CORESTA paper is probably as low as you will ever want to go on an inherently porous paper, and no more than 200 CORESTA on a perforated cigarette paper. This is not to discount the value of utilizing cigarette paper to reduce deliveries. It is standard industry

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

practice (USA) now to use porous cigarette paper on ventilated cigarettes. It is also used on some non-ventilated brands. With these limitations in mind, we are ready to examine the three variations of ventilated cigarette paper.

a. Inherently Porous

The porosity in inherently porous paper is a function of the manufacturing process during which it is made. The fiber distribution and alignment creates the void volume that creates the permeability. This was all discussed in the section on paper. Porous cigarette paper, as opposed to non-porous paper, is generally said to be less than 30 second (@ 17 CORESTA) paper. The ALTERNATIVES section discussed the types of delivery reductions that may be anticipated from various porosity cigarette papers. Switching from a non-porous to a porous cigarette paper can be considered a form of ventilation, because you are introducing more air into the tobacco column. Some purists might argue that because the paper is not physically perforated in any way, it is not true ventilation. Whatever you want to call it, the results are the same.

Inherently porous cigarette paper increases the burn rate as it becomes more porous, thus reducing puff count. Figure G.-1 shows typical delivery reductions for inherently porous paper, using a non-porous 12 CORESTA paper as the base point. These are different figures showing a similar cause and effect relationship that was illustrated in the ALTERNATIVES section. It is interesting to examine this graph, though, because it will be compared with an identical paper that was perforated. That chart will be shown in the following

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

discussion on perforated paper. At any rate, the tar reductions range from 9 - 24%, going from 20 to 70 CORESTA paper. Nicotine drops from 7 - 19% over that range, while CO ranges from 2 - 22% less. NO reduction is slightly less than CO, being 1% for 20 CORESTA paper and 19% for 70 CORESTA. Puff count, as you would expect, decreases with porosity. Table G.-2 shows the diffusion effect porosity has on CO. The absolute amount of CO being drawn from the coal decreases greatly for very porous paper, owing to the greater infusion of air through the cigarette paper. Therefore, the absolute amount of CO delivered and diffusing is less, even though the percentage diffusing is higher.

The conversion to inherently porous paper is relatively simple. Aside from changing your inventory, adjustments may have to be made in the burn rate, if desired. You may chose to simply lower burn time. The advantages of converting to porous cigarette paper have essentially been discussed. On the other end, the limited reductions possible are a disadvantage if you should try to squeeze more from the switch than is feasible. The upper limit of 8 second Greiner or 100 CORESTA porosity has also been well covered. In a nutshell, there is little to be said against it, other than higher cost and slightly less machinability.

b. Perforated

Perforated cigarette paper usually entails a lower porosity paper being electrostatically or mechanically perforated to create a physical ventilation, as opposed to the inherent porosity discussed above. One major difference is the ventilation process does not

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

change the burn characteristics, so the burn rate can be modified up or down. The puff counts can also be modified. Graph G.-3 shows the actual increase in puff count with porosity. This is due in this case to the resistance to burn created by the holes leading to less efficient puffing. The puff counts here are valid only for perforated 12 CORESTA base paper. Higher porosity base paper will decrease the puff count as expected. None of the four smoke components studied above show any appreciable change when moving from 12 to 20 CORESTA perforated paper. When the porosity is increased to 50 CORESTA, tar, CO and NO decrease 6%, 16% and 10%, respectively. At 70 CORESTA, these figures decrease again to 12%, 25% and 16%. Nicotine, as you will note, actually increases until it passes 100 CORESTA. Looking at Figure G.-4, we see a comparison of the porous and perforated cigarette paper study conducted by Owen, at Ecusta. This still uses 12 CORESTA as the zero reduction point. By substracting the delivery change of the perforated paper from the delivery change of the porous paper, we get the relative advantage (disadvantage) of porous vs. perforated paper in reducing deliveries. It is obvious the inherently porous paper significantly reduces the particulate matter more than the perforated paper. C.H. Keith of Celanese attributes this to an interaction between dilution and combustion. Owen notes that at equal CORESTA porosities, the perforated papers admit more air at lower pressures than porous paper, due to the larger holes. The exact effect of this on the smoke generated at the coal is not fully explained as of yet. The high molecular weight nicotine is not reduced at all by the perforated paper until high porosities are reached. Increased distillation of nicotine in the tobacco during smoulder period, and its subsequent

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

entry into the mainstream smoke afterwards, can be used to explain this phenomenon fairly well.

The gas phase reductions of perforated paper are slightly higher than for porous paper, as shown here. Selke, et. al. of Schweitzer, have shown that contrary to Owens data, inherently porous paper will allow relatively more CO to diffuse than perforated paper. They attribute this to a difference in the pressure drop-flow characteristics. The perforated holes contribute the bulk of the permeability of the cigarette paper, but don't add much to the total open area. In addition, the velocity of the air entering the holes is high, decreasing the diffusional possibilities for the holes. In contrast, the open surface area of inherently porous paper is much larger. These holes are sufficiently large to allow the CO to diffuse. Philip Morris data has tended to support these findings.

The disadvantages of perforated over porous cigarette paper have been mentioned. Depending on hole size, there can be an appearance disadvantage too. It is also usually more expensive. Since a low porosity base paper is used, it can give better opacity appearance, plus allow a higher total porosity, up to 200 CORESTA. However, when the porosity becomes too high, both the porous and perforated papers become difficult to light. Perforated cigarette paper has more variability than inherently porous paper. It is not widely used.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

c. Programmed

There is not much that needs to be said about programmed cigarette dilution. It is not currently used by any major manufacturer, nor is it likely to be. The theory behind it is still valid. The idea is to vary the dilution along the length of the cigarette to obtain a constant delivery. Not only could this eliminate one of the drawbacks of rod ventilation, that of changing dilution as the cigarette is consumed, it could also be used to compensate for the natural trend of higher deliveries at each subsequent puff, more or less. You can do this by increasing the ventilation with each puff. Figure G.-5 illustrates the puff-by-puff modification concept.

Programming is accomplished by coating perforated cigarette paper with a thermoplastic or sodium chlorate. The holes are not supposed to open up until the heat from behind the pyrolysis zone causes them to open, hence a "heat programmed" dilution. Some modification in the deliveries can be made by varying the perforation pattern and distribution.

Philip Morris and Brown and Williamson both test marketed a brand using programmed ventilation. Figure G.-6 shows the Puff-by-puff profile of these cigarettes, ys. a control. They were both discontinued after a short period of time. One of the problems with programmed dilution is the heat sensitivity of the coating. The temperature needed to open the holes was sometimes reached in shipping and storage, thereby "deprogramming" the ventilation. In addition, it has been found that each smoker

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essentially adjusts their own puff to get the desired smoke volume/delivery, making programmed delivery superfluous. For these reasons, Philip Morris has long since discontinued research on the subject. To the best of my knowledge, no one else is using it either.

2. Porous Tipping

Inherently porous tipping paper was originally the only method available to provide filter tip ventilation with invisible holes. It is available in cork and white tipping. Porosities are usually in the 300 to 2000 CORESTA range. The dilution range is about 10-50%. It can be used in conjunction with porous or perforated plugwrap. As with any type of ventilated tipping paper, a conscious decision as to the type of glue distribution must be made, as this will affect the degree of dilution. Porous tipping paper can achieve the same goals as any physically ventilated tipping paper. However, inventory carrying costs will be higher, because you will need a different tipping paper, or plug wrap, for each dilution level. If used within the range mentioned above, there should be no problems.

Porous tipping is used on a number of brands in Europe. The only company in the U.S. that uses it is Lorillard. Philip Morris does not use it because Lorillard holds a patent on it, requiring a royalty payment for its use. It is therefore cheaper to physically ventilate the cigarette than buy inherently porous paper. For that reason, there is no point in elaborating further, as no other U.S. manufacturer is using porous tipping.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

3. Hauni Pin*

Perforation of a filter cigarette is achieved by means of Hauni Pins or needles mounted in a rolling block. The outer wrap is closed on the usual rolling block. The additional perforating rolling block immediately rolls and perforates the cigarettes prior to the slitting drum. The first rolling block is usually set with relatively low pressure to the rolling drum. The perforating rolling block is set to press the cigarettes tightly only on the filter for perforation without mashing the tobacco column.
The second rolling block is equipped with two rows of needles which perforate the cigarette during the rolling operation.

Advantages

1. Low Cost
2. Standard materials can be used.
3. No glue applicator roller changes necessary.
   Ventilation may be introduced during the cigarette making process.

Disadvantages

1. Only 10-35% dilution may be achieved because the number of pins that a conventional assembler can accomodate is limited.
2. Hauni needles wear down so the process requires constant monitoring.
3. Dilution is a function of filter firmness.

* The above description is for a Max S tipping unit. With Max 3 only one rolling block is used.

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4. Molins CVS

The Molins CVS system over-perforates filter plugs. This system involves an alteration to the 5000 cpm plug delivery system of the Molins PA-8-5 plug assembler. The rolling drum and rolling guide are replaced with a new drum and guide equipped with pins which perforate the plug segments at one quarter or one sixth cigarette production speed. This means dilution level can be monitored by the ClD4-5, which has a digital readout. Dilution is controlled by the permeability of preperforated tipping.

Advantages:

1. Up to 70% dilution available.
2. Low capital cost.
3. Eliminates use of porous plug wrap.

Disadvantages:

1. Pins wear and perforation parts must be changed.
2. Requires skip gap or continuous glue free line.
3. Requires preperforated tipping paper.
4. Cannot be used on all equipment.

5. Electric Spark Perforation

a. Background

Zone perforation is used to describe the presence of perforations in a specified area of a product. In this case zone perforation is used to describe the process by which thousands of minute perforations are made in tipping paper in a specified band running parallel to the length of the paper. The width of the zone and the distance of the zone from the edge of the paper varies from brand to brand of cigarettes. In all cases, perforations must fall between

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the center and the two outer edges to which adhesive is applied. Figure A-1 illustrates the areas where adhesive is applied and the perforation band area which is glue free. Because the ESP perforates holes only in the tipping paper, the plug wrap must be porous in nature. Without porous plug wrap it would not be possible to dilute the smoke.

Figure A-2 illustrates the construction of a double wrapped filter cigarette. The area where tipping paper with adhesive overlaps the tobacco column is narrower than the area extending from the edge of the perforation zone closest to the point at which the filter cut is made to make two cigarettes. When perforating, the overlap area is the most critical area to maintain. Figure A-3 shows the tipping paper dimensions for the Marlboro brands. It is obvious from these three dimensions that as the cigarette length changes, the tipping width changes. The constant dimension is the distance from the inside of one band to the inside of the other band. In the case of P.M. USA, this distance is maintained at 24 mm so as to maintain 12 mm from the mouth end of the cigarette to the beginning of the perforated band.

It is important to ensure that the perforation zone does not overlap the adhesive area and reduce ventilation. Different combinations of tipping paper and perforating electrode heads are used to vary those dimensions.

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b. Component Modifications

With past perforating techniques such as Hauni Pin and Molins Needles, the chemical composition was relatively unimportant. The use of ESP however, requires certain quality standards for the composition of the paper. Chemical reactions occur which deposit different residues on the spark gap electrodes. This residue causes a deposit to build up on the electrodes which will cause tears and breaks in the paper. This has all been covered in detail in Section D., PAPER. However, due to the importance of these factors, I would like to repeat the key changes necessary when perforating using the ESP method.

The following are the acceptable levels of critical components for perforation of cork base sheets. These critical limits apply to P.M. U.S.A ESP perforating systems and conditions.

	Desired Level	Maximum Level
Fe_2O_3	0% to trace	1%
Clay (Silicates)	0% to trace	2%
* $CaCO_3$	13 - 15%	-

$CaCO_3$ an opacifier has a cleansing effect on the electrodes at these levels. TiO_2 is particularily critical. Organic compounds tend to have no adverse effect on perforating, while inorganic compounds tend to deposit on the electrodes.

With respect to inks, the vehicle to pigment ratio (organic/inorganic) ranges from 60/40 to 75/25 under ideal conditions. The higher the organic components level the lesser the amount of electrode deposits. Cork inks with a 35/65 vehicle/pigment level will not perforate well on the best azo dyed sheet.

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C. Principles of Operation

The function of the ESP Perforator is to create a high frequency of electric sparks or arcs between the electrodes. These electrodes are arranged to give the desired zone of perforations in the paper. Alternating current up to 12,000 volts RMS developes the arcs across the electrodes. Alternating current changes polarities each 1/2 cycle, so it is expected that a single arc would be developed each time the voltage went from 0 - 12,000 U and back to 0. (The slide illustrates alternating current). Actually this is not the case. Many arc-overs occur during each rise and fall each 1/2 cycle due to the Townsend effect. The slide illustrates this effect. The basic arrangement of electrodes with free air space ions is shown. Notice in the outer rings of the ions there are many electrons. As voltage is applied to the negative electrode, there is a rapid build up of electrons. As the voltage level increases, the pressure exerted by the buildup causes the electrons to leave the electrode at high velocities. These highly accelerated electrons collide with free space air ions knocking off several of its electrons. Millions of electrons leave the electrode at one time. Electrons from free space air ions bombard other free space air ions creating a chain reaction. The opposite electrode provides a strong point of attraction for the released electrons across the air gap between the electrodes. This phenomenom creates what we perceive as the electric spark.

The flow of electrons continues as long as electrons leave the negative electrode. After this first surge of electrons bombard the free air space ions, they are soon depleted of free electrons and process is quenched. This quenching effect places a limit on

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the number of holes that can be placed in the paper for a given time period.

To improve this situation, the depleted ion must be removed at a faster rate. This is done by blasting air across the electrodes at sonic velocities. It blows depleted ions out and replaces them with fresh air, resulting in a large number of arc-overs during a 1/2 cycle. Two sonic air jets are used on each electrode to achieve this, as well as to cool the tungsten electrodes.

The above description implies that for each arc over, a new hole is burned. This would be true, except that the paper is not traveling fast enough to permit it. This perforation technique, the multiple spark effect, creates one large hole for better ventilation, rather than several smaller holes.

When an arc-over occurs, a hole is blasted through the paper. The air jets remove the dust and ions. The quenching effect interrupts the arc as the paper moves farther along. A second arc-over occurs in which the electrons will take the path of least resistance, that being the hole formed during the first arc-over, even though the hole is not directly over the electrodes. This arc over quenching effect continues creating a larger hole each time. This continues until the hole is far enough away from the electrodes that the distance offers more dielectric strength than the new paper area between the electrodes.

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Controlling Pressure Drop of the Paper

The pressure drop of ESP tipping is controlled as follows:

1. Porosity of the paper increases, i.e. ΔP decreases as paper speed decreases and current increases.
2. It is possible to increase or decrease electrode gap to change the ΔP, but this method is normally used only when low permeability tipping is desired and cannot be achieved otherwise.

Advantages of ESP Paper

1. Non visable at low permeability.
2. Good uniformity of permeability despite hole size variations.
3. Pressure drop of paper is relatively easy to change.

Disadvantages of ESP Paper

1. Current methods do not allow high permeability without seeing burned edge appearance.
2. Requires relatively expensive porous plug wrap.
3. Requires skip gap glue applicator or continuous glue free line because of slow speed and burn marks.
4. Maximum ventilation practice 30 - 35%.

6. Mechanical Perforated Tipping Paper

a. Background

The dilution level of a cigarette with mechanically perforated tipping depends on the number and size of the perforations and the porosity of the plugwrap. By manipulation of perforation size, number of perforations and porosity of the plugwrap, a continuous spectrum from 10 to 95% dilution can be obtained.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Perforations are always visible and are not consistent in size and shape. Nonremoval paper can close holes during rewinding. The best uniformity of dilution with mechanically perforated paper is in using multi-row perforations and controlling dilution with the degree of permeability of the plugwrap.

TIPPING	PLUG WRAP PERMEABILITY	DILUTION %
5 row mechanical	350 cm/min	22%
5 row mechanical	5700 cm/min	48%

This method, as we used it, permits the use of large rolls of paper with seven print patterns, plus a guideline to be perforated by a single pass through the machine. The roll is 34 inches in diameter and will yield, after processing, 35 finished bobbins. Actual running time through the mechanical perforator at the current running speed of 700 ft./min., is about 65 minutes. The perforated paper is rewound and subsequently must be slit into seven strips across the width on another machine. This other machine also subdivides the roll into the 35 finished bobbins. Our present slitting speed is approximately twice that of perforating speed. Some time is lost in the slitting process since it must be stopped at the prescribed bobbin size, finished bobbins removed and labeled, and new cores put in place to continue the subdivision of one master roll to 35 finished bobbins.

Overall, considering loading and unloading time, the output of the perforator is approximately equal to that of the slitter. Except for handling the large master rolls, which requires mechanical lifting equipment, one attendant can operate both machines.

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The perforating machines we use were built by A.B. Produktion Services APS of Vallingby, Sweden. They consist basically of an unwind stand with integral tension control means, a perforating section, and a rewind section with adjustable roll density means. It was found to be financially unfeasible for Philip Morris to do their own mechanical perforating.

b. Machine Operation

The paper is drawn through the machine by means of a "surface drive" friction roller driven at a surface speed equal to that of a perforating tool disc. The paper has previously been "threaded" around a number of free-turning rollers which equalize the stress across the paper web width and flatten out wrinkles which may exist in the master roll. Tension on the paper is constantly maintained by a "dancer" roll mounted on a pivotable frame supported by the paper web motion of this frame which, due to changes in web tension, acts to control brake on the unwind shaft (carrying the 34" master roll), which increases or decreases its braking action to restore the desirable tension.

The perforation of the paper is accomplished by having the paper pass under and in contact with tool discs. The periphery of these discs consists of teeth formed to the size and spacing of the desired hole pattern. The tool discs, which resemble circular saw blades, are assembled with supporting spacers in between them and are spaced axially along a shaft at distances equal to the spacing of the multiple print patterns across the width of the master roll. A high speed cutter, long enough to span the full paper width is

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moved up under, and in contact with, the paper by an eccentric roller controlled by a servo-motor. The cutter mills away the paper that is in contact with the teeth of the tool discs, but fails to touch the teeth by a distance of only a few microns. The remaining few fibers of paper are punched through by the teeth in the disc to form a clean hole of the same size and shape as the teeth. The distance between the cutter and tool disc teeth is sensed by measuring the electrical conductivity of the paper and comparing this value with a pre-set standard. This system is made possible by having the cutter and its mounting means electrically isolated from the rest of the machine. A differential error detected by the comparison of the two values causes the servo-motor to raise or lower the cutter to restore the proper reading. If, by chance, the cutter actually makes electrical contact with the teeth, the machine is automatically stopped and the cutter is immediately dropped clear.

The guideline, printed on the paper when the decorative pattern is put on, works in conjunction with a photo-electric sensor to actuate a hydraulic paper guide system to insure that the multiple rows of holes are put in correct relationship to the print pattern.

After being perforated and rewound into a master roll again, the rewound roll is placed on the unwind shaft of the slitter machine. Using a similar guiding system, the web or paper is accurately drawn through the shear-type slitting knives and rewound on seven shorter cores to a pre-determined strip length. The extra width of web necessary to provide space for the guideline on one side and

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trim width on the other, is trimmed off and collected by rewinding on suitable shorter cores.

As mentioned earlier, the slitter is equipped with a length measuring counter which stops the machine after the pre-set length of paper has passed. At this point the finished bobbins are removed, trim disposed of, and new cores placed on the rewind shaft, etc.

The advantage of this method of perforating tipping paper is that by disassembling the tool shaft and replacing the tool discs, you can change hole size and hole spacing, thus varying dilution percentage.

7. Laser

a. Philip Morris

The Philip Morris System for Laser Perforating tipping paper encompasses technology and state of the art not generally known throughout the industry and is essentially sensitive in nature. Currently this system is discussed only in general terms in the absence of a secrecy agreement.

Our system offers the following:

1. Our system covers all ranges of dilutions, in general 5% - 95% + dilution.
2. Our Laser perforated tipping for low ventilation level can be run at 5000 FPM.
3. We operate in the range of 20 - 70 holes per row. Ventilation level i.e. pressure drop of the tipping

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is controlled by varying hole size, holes/inch, number of rows.

b. Hauni On Line

Hauni supplies a laser perforating system which is installed on Max S and Max 80 tipping units.

A gaseous mixture of CO_2-N_2-He flows through the resonator tube. CO_2 molecules are excited by a HT voltage (electrodes) in the resonator. The laser beam is produced between the end mirrors of the resonator. Part of the light energy passes through one of the end mirrors which decouples the beam. A deflection mirror directs the beam to the perforation units. The beam guides form a totally enclosed system. 85% of the laser light generated is presented to the perforating system. From the generating point at back of the machine, the beam is transported via a series of mirrors to the beam splitter placed above the rollers. The rolling mechanism consist of a special rolling drum and smaller segmented disc, turning in opposite directions. Each double cigarette is turned 360°. The cigarette tip while turning maintains the same lateral position with respect to the beam splitter. The filter tip is perforated evenly and precisely by the laser beam.

Cigarettes may be ventilated from 10 - 60% at 4000 cigts/min. The width of the perforations is controlled by the focal length and the length of the holes by the pulse time. Hole diameters range from .05-.3 mm. The maximum degree of dilution is controlled by production speed and materials used.

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c. Macro vs Micro

Macro Laser - The basic distinction used by P.M. for macro laser versus micro laser is the visibility of the holes. Macro laser holes are visible, micro laser holes are not visible. Typical open area for macro laser holes range from .5 mm^2 to 3.0 mm^2. Dilution available for macro laser range from 10 - 95% +.

Micro Laser - The holes are invisible. Typical open areas of the holes range from .075 mm^2 to .3 mm^2. Dilutions of 10 - 60% are available with micro laser perforations.

Page G.-21a lists the types of ventilation systems and the levels of ventilation available for each one. Also listed are the advantages and disadvantages for each.

8. Typical Laser/ESP Capabilities

With ESP perforating, it is important to establish a pressure drop that will optimize machine speed and voltage. For the example presented, this was achieved between 10.5 cm at 18 cm. So to achieve a ventilation level, it would be necessary to chose the pressure drop target between 10.5 and 18 cm and select the plugwrap that would achieve the desired level of ventilation.

The example given shows plugwrap permeability and tipping pressure combination necessary to achieve various dilution levels. The methods for achieving the various pressure drop by our laser is proprietary.

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DILUTION TECHNIQUES

TYPE	DILUTION RANGE		ADVANTAGES (+) or DISADVANTAGES (-)
Hauni Pin	10-35%		± No Additional Processing Steps + Nonporous Plug Wrap - < 4000 Cigt./Min. - Pin Wear, Replacement - Visible Perforations - Poor Dilution Uniformity
Hauni Laser	10-40%	Parliament 80 85 100	+ No Additional Processing Steps + Nonporous Plug Wrap - Visible Perforations
Pre-Perforated Tipping	10-95%		+ Off-Machine Perforating - Porous Plug Wrap, Skip Tipping = Extra Processing Step
Mechanical (Macro)	10-90%	Virginia Slims Light Marlboro Lights B+H Lights	+ Master Roll Perforation + Readily Available = Ragged Perforations
Electrical	10-40%	Marlboro 80 85 100 B+H 100's Menthol Virginia Slims	+ Unobstrusive Perforations + Good Dilution Uniformity - Special Tipping Compositions - Limited Availability (Use)
Laser-Macro	10-95%	Cambridge 2 rows 4 rows 8 rows	+ High Processing Speeds + Good Dilution Uniformity - Large Capital Investment
Laser-Micro	10-60%	Merit 2 rows Saratoga 2 rows	+ Unobstrusive Perforations + Good Dilution Uniformity + High Processing Speeds - Large Capital Investment
Porous Tipping	10-50%		+ No Visible Perforations + Lower CO Delivery - Appearance Differences - Competitive (B & W) Patent

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9. Industry Practices

It should be clear by now that there are a number of viable methods available to you for ventilating cigarettes. Their limits, advantages, and disadvantages have all been discussed. In order to put the types of ventilation into some kind of perspective, I would like to briefly run through the types of ventilation that have been used in the past four years in the U.S. cigarette industry and the direction each company is heading. While this may not seem relevant to some people, it will serve to illustrate the diverse philosophies of each company, that there is no industry consensus on one best ventilation method. It is important to remember that it is often patents and economics, more than philosophies, that determine the ventilation product mix.

Philip Morris uses more types of ventilation than any of the other companies. The list will be shortened to four methods in the next few months, as the last three Hauni pin brands are phased out. These are three very limited production brands, so for all intents and purposes, they are no longer used. Philip Morris has been the only company using Hauni pins for a long time. The number of ventilated brands jumped 50% over the four year period, so virtually all of our filtered brands are ventilated. The main change over the period, other than the Hauni pin, has been the conversion to laser perforation. The number of brands ventilated in this manner will only increase. A recent addition has been the perforation of the Parliament Lights line by On-Line Hauni lasers. PM was the first company to use micro-laser perforation. This was introduced in 1980

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on the Cambridge family of cigarettes, all highly diluted.

R. J. Reynolds has and does rely chiefly on mechanical perforation. They use it over the entire range of dilution levels. They have recently begun to electrostatically perforate their bread and butter brands, the Winstons, Salems, and Camel filters. These are the brands that have been moved just inside the low tar limits. Reynolds, like Philip Morris, has also perforated their entire filter line.

American Brands has favored laser perforation and have not altered their philosophy. They have expanded the number of brands that are diluted. All of these newcomers have been laser perforated. The Carlton Box, the "No Tar Brand", has laser holes much larger than standard laser holes.

Brown and Williamson, like Reynolds, use mechanical perforation as their staple method. Electrostatic, laser and on-line laser are each used on one brand. It almost seems as though they want to stay abreast of what is going on in these other ventilation method areas, possibly using them as development or contingency projects.

Lorillard is the only company using porous tipping paper, for reasons that were mentioned earlier in this section. However, mechanical ventilation is still their principle method of choice. They have just begun ventilating their Newport brands with micro-mechanical ventilation, at a very low level of dilution. They are the only company currently using that method.

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Liggett and Myers only uses two types of perforating methods. Three years ago laser was the only method used. While no more brands have been ventilated since that time, two brands have been converted to mechanical perforation. Liggett differs from all of the other manufacturers in that they do no low-range ventilation, at least 39%. Liggett purchases all of their pre-perforated tipping from outside vendors. In addition, all the low-tar generic brands produced by Liggett are ventilated. They are not included here.

In summary, half of the companies have made mechanical ventilation their method of choice. It is also the only method used by all six companies. Laser is the up and coming challenger. There are still a lot of brands that are electrostatically perforated, and on-line lasers are making some in-roads. Hauni pin is definitely out. Micro-mechanical may catch on, but it is doubtful porous tipping will be used outside Lorillard.

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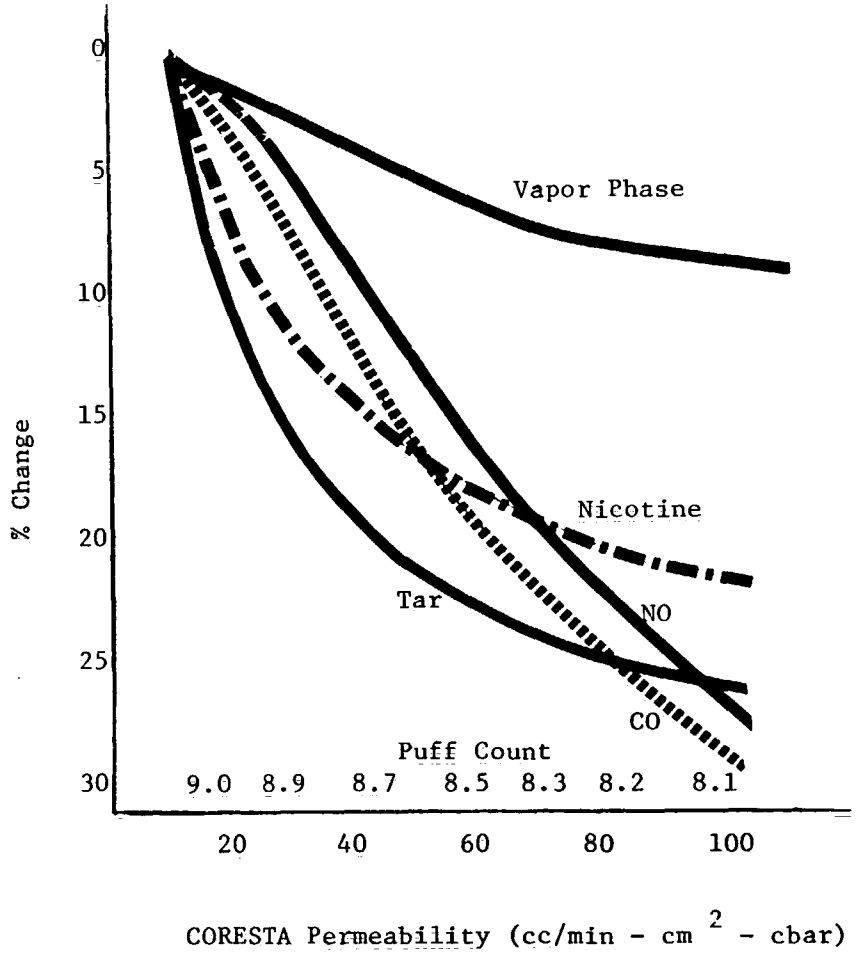
PERCENT CHANGE IN YIELD AND COMPOSITION PER CIGARETTE
WITH INHERENTLY POROUS, 0.5% CITRATE PAPERS



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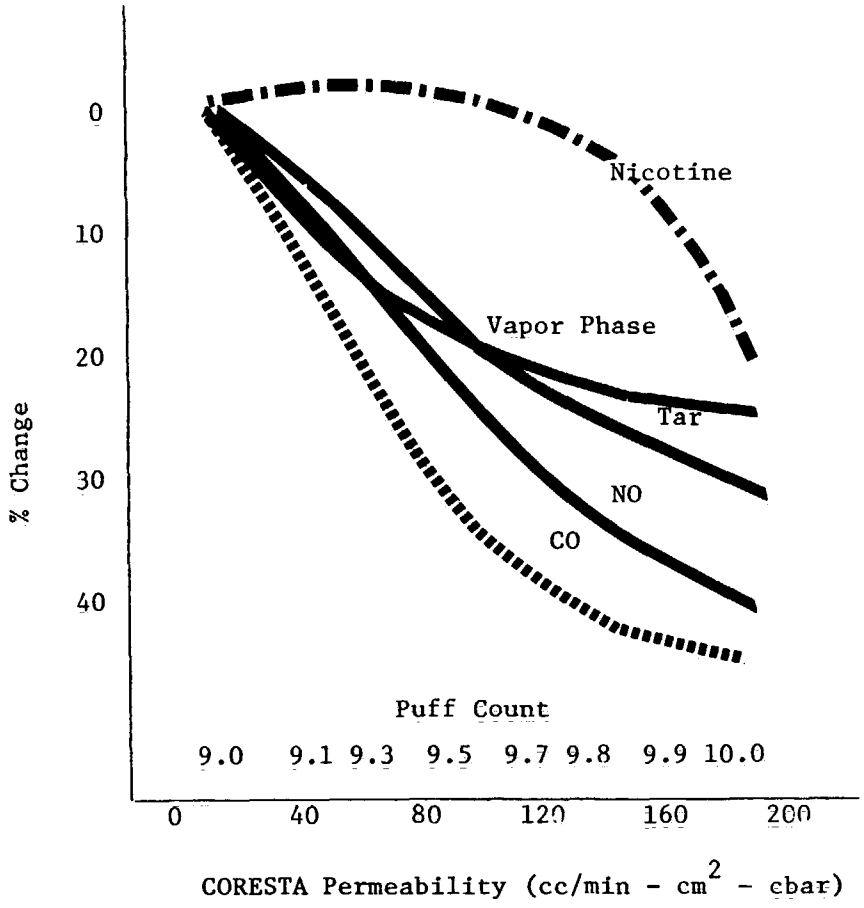
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

PERCENT CHANGE IN SMOKE YIELD AND COMPOSITION
WITH PERFORATED, 0.5% CITRATE PAPER



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* POROUS vs PERFORATED CIGARETTE PAPER

	CORESTA 20	CORESTA 50	CORESTA 70
TAR	+ 8 %	+ 15 %	+ 12 %
NICOTINE	+ 7 %	+ 17 %	+ 21 %
CO	0	- 1 %	- 3 %
NO	0	+ 3 %	+ 3 %

* From Owen's Ecusta Graphs shown earlier, the numbers represent the differential percentage reduction in deliveries achieved by porous paper vs. perforated paper, using 12 Coresta as the base (zero reduction) point.

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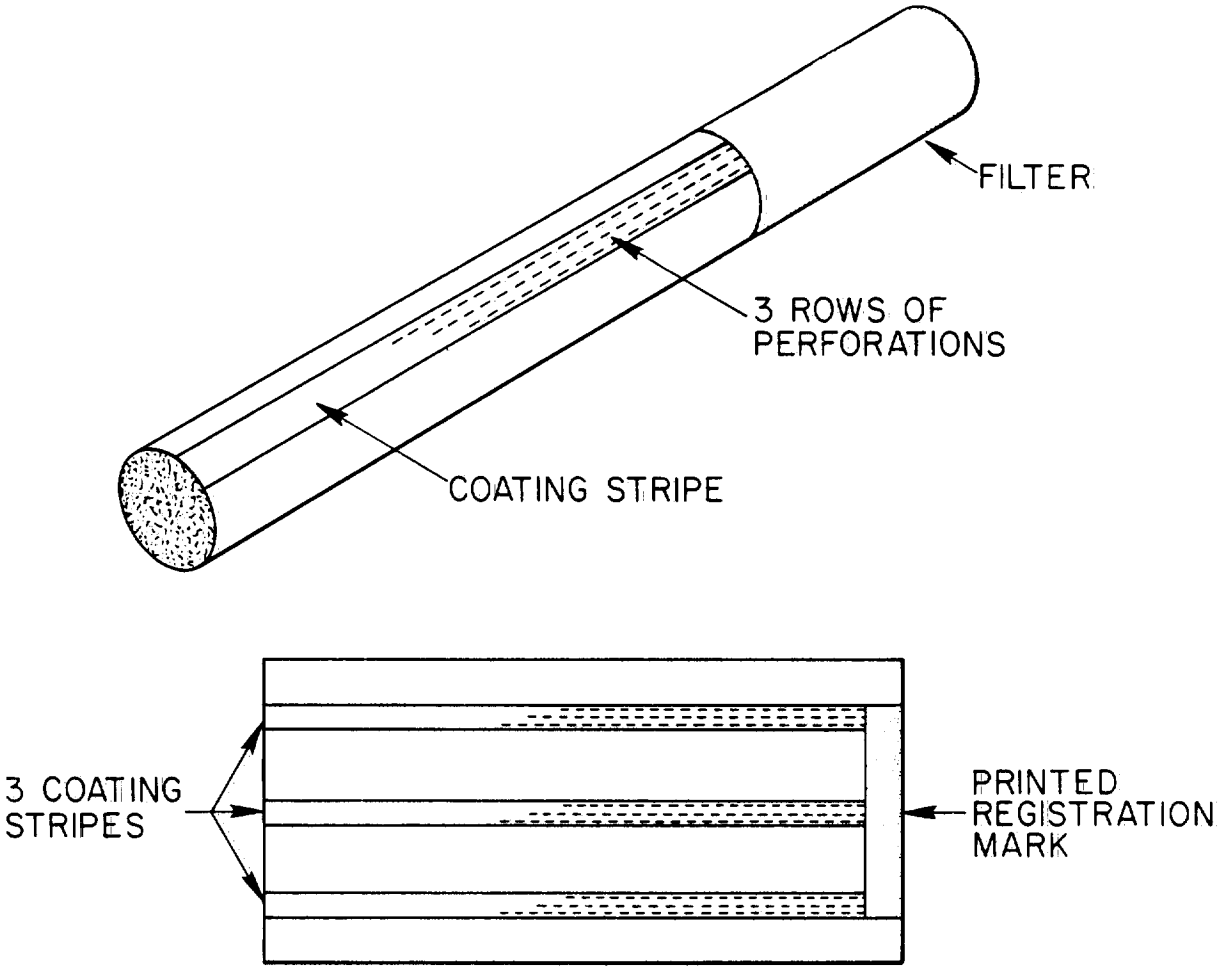
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EXAMPLE OF PROGRAMMED VENTILATION FIGURE **G-5**



A controlled-profile cigarette. The coal melts the coating stripes, allowing ventilation of the rod via perforations in the cigarette paper.

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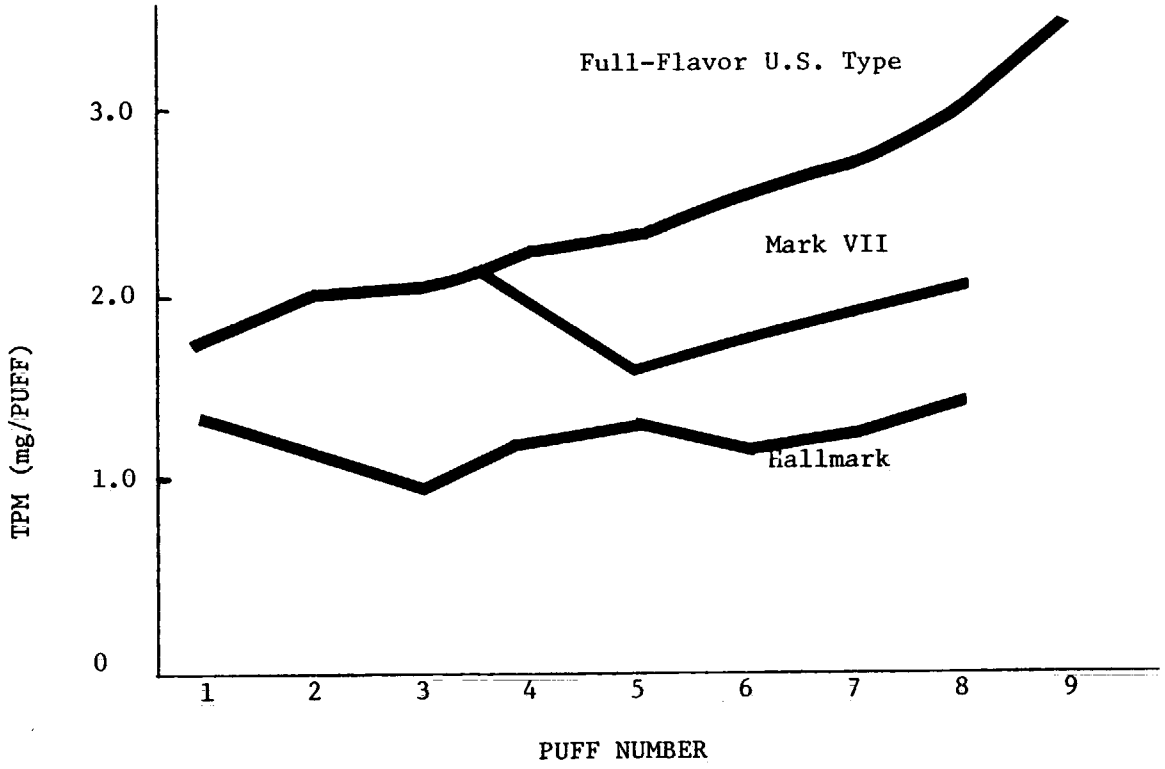
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000



TPM vs. puff number for a full flavor, U.S. type cigarette and 2 controlled-profile cigarettes. Notice how the tendency for TPM per puff to increase on later puffs can be moderated by the controlled-profile design.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

VENTILATION TRENDS

PHILIP MORRIS

	1979 NUMBER OF BRANDS	1982 NUMBER OF BRANDS	DILUTION RANGE %
MECHANICAL	6	7	21-30
ELECTROSTATIC	12	14	10-16
LASER	2	18	29-95
LASER (ON-LINE)	0	3	31-36
HAUNI PIN	10	*3	13-24
TOTAL	30	45	10-95

* TO BE CONVERTED TO LASER IN THE NEXT FEW MONTHS

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VENTILATION TRENDS

R. J. REYNOLDS

	1979 NUMBER OF BRANDS	1982 NUMBER OF BRANDS	DILUTION RANGE %
MECHANICAL	18	28	17-93
ELECTROSTATIC	1	5	14-23
LASER	0	1	26
TOTAL	19	34	14-93

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

VENTILATION TRENDS

AMERICAN BRANDS

	1979 NUMBER OF BRANDS	1982 NUMBER OF BRANDS	DILUTION RANGE %
MECHANICAL	3	2	23-60
LASER	16	23	12-97
TOTAL	19	25	12-97

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

VENTILATION TRENDS

BROWN AND WILLIAMSON

	1979 NUMBER OF BRANDS	1982 NUMBER OF BRANDS	DILUTION RANGE (%)
MECHANICAL	10	13	23-83
ELECTROSTATIC	1	1	15
LASER	1	1	26
LASER (ON-LINE)	0	1	30
TOTAL	12	16	15-83

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

VENTILATION TRENDS

LORILLARD

	1979	1982	DILUTION RANGE (%)
	NUMBER OF BRANDS		
MECHANICAL	13	18	15-66
POROUS TIPPING	8	8	24-47
MICRO-MECHANICAL	0	2	6-7
TOTAL	21	28	6-66

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

VENTILATION TRENDS

LIGGETT AND MYERS

	1979 NUMBER OF BRANDS	1982 NUMBER OF BRANDS	DILUTION RANGE (%)
MECHANICAL	0	2	52-54
LASER	7	5	39-60
TOTAL	7	7	39-60

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

H. EFFECTS OF PERFORATION VARIATIONS

We have seen the various methods that can be used to ventilate cigarettes. Each has their own characteristics and different levels of variations. These too, have been pointed out. However, we have not as yet explained the effects upon design parameters that these variables can cause. What effect upon dilution level is caused by a larger hole size? What happens to smoke deliveries if I move the vents 3 mm further from the mouthpiece? How should I determine the number of rows of ventilation? By the end of this section, you should have a good understanding of the effects of perforation variations.

1. Size of Holes/Number of Holes

The study of hole size variation is difficult to separate from the total number of holes. Initially, they were to be covered in succeeding sections. From a realistic standpoint, one really speaks of the trade-off between fewer, larger holes vs. more, smaller holes. The effect of increasing the number of holes, leaving hole size constant, is obviously going to be an increase in dilution and a decrease in smoke deliveries. The effects of varying hole size and the number of holes is not so simple. Some sophisticated studies have been conducted that illustrate the use of smaller holes is more efficient than large holes. After briefly discussing the theory behind this, several graphs and tables will be shown to support the theory. A detailed study requires a liberal dose of physics, and is not the intent of this section.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

A typical ventilated filter consists of the tipping paper, adhesive, plugwrap, and acetate. We will assume the use of porous plugwrap, as is standard practice. As you have discovered by now, the hole sizes vary from hole to hole. However, these fall within some range, so that an average hole size can be determined. The area of the holes is in fact, not the actual area that determines the degree of dilution. The area of the hole perforation is the "nominal" area. Figure H.-1 shows a blow-up cross-section of the perforation area. The glue-free area extends beyond the hole on both sides. This is to allow for the natural variation in the perforation process. Because of this, there is a gap around the hole between the plugwrap and the tipping paper. Mathews and Selke of Schweitzer Division Research Laboratories have shown a significant lateral airflow occurs between this gap, but not over the entire unglued area. They found for large macro perforations, on the order of 300 microns, that the air escaped about 0.1 mm in all directions from the hole. For small micro holes, about 50 microns in size, this figure dropped to 0.05 mm. This phenomenom creates an "effective" dilution area that is greater than the actual perforation hole size. The effective area is some factor of the nominal area.

The factor for micro-type holes has been found to be about 9 times, while macro-type holes only show a 3 times gain over nominal area. The reasoning behind this is not clear at first, but Figure H.-2 should help explain the difference. It should be obvious that these factor numbers must be re-calculated as hole size strays further and further from the reference sizes.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

"d" represents the diameter of the actual perforation. "Δ" is the difference between the radius of the perforation and the radius of the effective area. Thus, "D", the diameter of the effective area, can be represented by $d + 2\Delta$. Plugging these variables into formulas for the area of a circle, then algebraically reducing them to its simpliest form, yields the equation $\frac{A}{a} = 1 + \frac{4\Delta}{d} + \frac{4\Delta^2}{d^2}$. Looking at this, we can see that as the diameter of the perforation increase, the ratio of the effective area to the nominal area decreases. This reverts back to the formula for the area of a circle being geometric, not linear. An increase in diameter from 1 mm to 2 mm will increase the area 400%, but a similar 1 mm increase from 6 mm to 7 mm increases circle area only by 136%.

The effective area is determined by more than hole size. The roughness of the plugwrap, the permeability of the plugwrap, and the tightness with which it is assembled to the tipping paper can all significantly alter the effective area. This will vary from one maker type to another, among other things. In some instances, different makers producing the same ventilated cigarette may have to use different porosity plugwraps to achieve the same dilution levels, due to large variations in tipping - to - plugwrap tightness.

The bottom line is that more, smaller holes offer a greater effective area for dilution than fewer, larger holes. The possibility of overlapping effective areas, hence less efficient perforation, also exists more with larger holes than smaller holes. This normally will not come into play until ultra-high dilution levels are reached.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

To cite some examples, Figure H.-3 shows the variation of hole size and hole number on cigarettes perforated at a typical distance of 14 mm from the mouthpiece. This is an early study, so the holes are all of macro-type size. Pressure drop decreased, as expected, both with increasing hole size and hole number. You can see a greater increase in dilution level can be achieved by increasing the number of vents than by increasing the hole size. Using the smallest hole, .254 mm, a greater increase in dilution level is effected by increasing the number of vents from 2 to 6 than by increasing the hole size from .254 to .457, at 2, 4 or 6 hole level. This is true in absolute and percentage increase terms. Figure H.-4 shows this. While the absolute increase in dilution with increasing hole size remains constant, the relative increase keeps dropping. The nominal area increase at both the 4 hole and 6 hole level is greater when increasing hole size than when increasing hole number, but the theory demonstrated earlier is borne out by the results here.

Celanese has completed a more recent study on hole size and hole number. They have used smaller holes, from .050 mm to .190 mm. The former is a typical micro size hole, while the latter is a small macro hole. One difference is this study varied the hole size and kept the hole number constant. The hole size was varied to maintain a constant tipping paper permeability. Graphs H.-5 through H.-8 show the relationship between hole size and dilution, tar, nicotine, and CO, respectively. In all cases, the 60 holes per inch was able to register more dilution, thus lower deliveries, at an equal tipping paper permeability. The differential between

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

the lines increased as the permeability of the tipping increased. This means the relative advantage of the 60 HPI line over the 28 HPI line increased over the range of 500-4000 CORESTA tipping paper permeability.

Both studies substantiate the case for using a greater number of small holes to ventilate rather than a fewer number of large holes.

2. Location of Holes

Another important variation in the perforation variability is the location of the holes in relation to the mouthpiece. It is a reliable rule of thumb that the closer they are to the mouthpiece, the higher the dilution and lower the smoke deliveries. For practical purposes, the vents cannot be too close to the end of the filter or the smoker will cover them with his mouth when he smokes the cigarette. Therefore, cigarette manufacturers have basically chosen an optimal hole starting point in the 11-19 mm range and not varied that parameter much.

As the holes are moved closer to the mouthpiece end, pressure drop decreases because the air entering the filter has a shorter distance of the filter to penetrate. Upstream pressure drop increases, and as it does, so does dilution level. Graph H.-10 illustrates the relationship between pressure drop and hole size for several different dilution levels. In every case, the pressure drop decreases as the hole location is moved over the standard range from 19 to 11 mm from the mouth end.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

The decrease in pressure drop is augmented in both relative and absolute terms as the dilution level increases. At 25% dilution, moving the holes from the furthest point to the closest lowers pressure drop 5%. However, at 50% dilution, the pressure drop decreases 10%, and at 67%, it drops 14%.

Figure H.-11 illustrates the effect of vent location upon per puff ventilation. All three lines have the same general shape, where dilution increases for the first two puffs, then decreases and levels off. You will notice, though, that the closer the holes are to the mouthpiece, the less variation there is in the curve. The dilution level operates over a smaller range. The initial increase in ventilation can be attributed to the formation of the coal. This increases pressure drop upstream of the vent, which as you already know, also increases dilution. The dilution level then decreases as the tobacco column decreases in size, and of course, pressure drop. The reason the dilution level varies less as the holes approach the mouth end is that the dilution level of "A" is less dependent upon the changes in the tobacco column length because its upstream pressure drop incorporates a larger segment of the filter. This serves to buffer the changes in rod length.

As expected, tar and nicotine deliveries decrease as the vents are moved closer to the mouthpiece. Using the same distances as Figure H.-11, we can see in Figure H.-12 the changes that occur at these distances. The number of vents also varies, but the average reduction for each hole position follows the logical

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

trend. Using 17.8 mg tar and 1.36 mg nicotine as the base, the most efficient removals occur 7 mm from the mouth end. Even at the more practical 14 mm point, nicotine removals are twice the differencial percentage as at 21 mm, and the tar differential percentage is half as much again. Using different data, Figure H.-13 illustrates this effect in graph form. Once again, nicotine removals are effected more than tar removals, lowering the nicotine to tar ratio. The lower smoke velocity over a longer filter area can be used to explain the decrease in the particulate phase. Figure H.-14 offers a good comparison of a number of factors influenced by vent position. All of the parameters are summed up here, except dilution variation. A constant 50% dilution level (approximately) is maintained throughout. Figure H.-15 illustrates the anticipated greater effect upon TPM deliveries that vent position has as dilution level increases.

I do not have any graphs on vent position vs. CO delivery, but Celanese has found it to have little or no effect. This is probably because a good deal of the CO escapes through the wrapper, and most of the remainder, through the vents. Therefore, as the length and time of exposure within the filter medium are not a major factor in the removal of CO, the actual position of the vents should not have much bearing on its removal efficiency.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Vent location has been found to have no consistent effect on taste. In conclusion, the vents should be positioned near the mouth end, but a safe distance from where the smokers lips will be. Once this optimal minimum distance from the mouth end is found, you will maximize your efficiencies by not using vent location as a design variable.

3. Number of Rows

While there has been a lot of research done on hole size, number, and location, there has been very little performed on the number of rows of vents. What research that has been done is indirect, ie. hole location as it relates to the number of rows. In essence, there is not the void that seems to exist on the surface. That is because the number of rows is really determined mainly by the dilution level and the type of ventilation process. Once this is explained it should be obvious that row determination is not a complex issue. In the case of electrostatic perforation, row number is not pertinent, as it is a band, with no discernable rows.

Recalling the discussion on hole size and number, you can determine a practical configuration of holes per row for a given hole size. You do not want their effective areas to overlap, if possible, as this "wastes" the usefulness of part of the perforation. With a reasonable hole size, there is a limit to the number of holes you can put in a row. Beyond that point, you should use another row of perforations.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

The second major concern is the type of machine. With the laser, for example, although it is possible to perforate using various row numbers, certain numbers provide more efficient use of both energy and machine. Time can also be a factor, as other types of ventilation can also operate different row combinations, but can do some quicker than others, hence less conversion cost. Optimizing the efficiency of the perforation machinery is usually the most important determinent of row number. This obviously must be done within the range capabilities of the machine.

Another consideration influencing row number is the issue discussed immediately before, that of hole location. Whenever you use multiple rows, you must increase the distance some of them are from the mouth end, or move the first row towards the mouth end. The average distance of the rows from the mouth end is a good approximation for use in ventilation calculations. However, by adding rows, and moving them away from the mouth end, you will be diminishing the efficiency of the rows further out. To partially offset this, some manufacturers use a constant average distance from the mouth end for the rows, rather than a constant starting point. In light of the available information, there is not much more that can be added to the issue of row number at this time.

4. Industry Practices

The theories behind perforation variations must be balanced by the practicalities of production. This in no way negates the importance of understanding perforation variations. From a realistic viewpoint, it is sometimes necessary to optimize machine efficiency rather than,

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

say hole size. The tradeoff is not this simple, but it does give an idea of the priorities. Generally speaking, hole size is more a function of the ventilation type than anything else. It is difficult to control within tight parameters. The actual hole size can usually be modified within a range by varying some machine variable ie. speed, voltage, etc. The starting point of the holes is also usually fixed. Machine changes are necessary to change the starting point, possibly part changes too, so there is a conversion cost for altering the starting point. The number of rows, as stated earlier, is usually determined by what the machine can run most efficiently. Hole number, then, seems to be the main variable to alter dilution within a row, then more rows are added to meet dilution target. Hole size, rather than number, may be increased. There are too many considerations to derive reliable rules you can follow. Each situation should be examined to determine how to proceed.

Figure H.-16 shows some of the perforation variation parameters we have been discussing as they pertain to the U.S. cigarette industry. Hole size is not covered. It is important to note these are actual measurements, on a sample of cigarettes. Because of this, there will be variations from the specifications. For example, Philip Morris specifies almost all of its brands at a 12 mm hole starting position for the perforations. Mechanical bands are specified at 12.5 mm. The specification is normally listed as $\pm$ 0.5 mm, but most ESP brands are listed at $\pm$ 1 mm. This is on the tipping paper, so the specification actually quotes the distance between perforations on the uncut bobbin, so that 24 mm $\pm$ 1 mm will translate into 12 mm

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

$\pm$ 0.5 mm for the cigarette once it is cut. Measuring cigarettes, rather than tipping paper, also injects the eveness of the cigarette cut as a variable. Therefore, this table is only intended to be used to give you a general idea of the diversity that exists in the choice of perforation variation parameters with the U.S. industry. It is not a specifications listing. While exact comparisons are not reliable based on this data, it is safe to conclude such things as both Brown and Williamson and Liggett and Myers products have the start of their perforations about 2 mm further away than Philip Morris brands. The average row distance for American Brands is about the same as Philip Morris, but significantly less than the other four companies. Nobody uses more than a 10 mm band width, less than an 11 mm starting point, nor more than 8 rows. This is the type of information that can be derived from Table H.-16.

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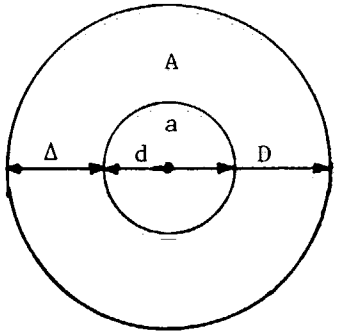
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H. 2



d = nominal diameter of perforation

D = effective diameter of perforation system

Δ = difference between radius of D and radius of d

a = nominal area of perforation

A = effective area of perforation system

* $a = \frac{\pi}{4} d^2$ $\qquad A = \frac{\pi}{4} D^2$ $\qquad D = d + 2\Delta$

$A = \frac{\pi}{4} (d + 2\Delta)^2$,

$\frac{\text{effective area}}{\text{nominal area}} = 1 + \frac{(\text{outward 4 diffusion})}{\text{diameter of perforation}} + \frac{(\text{outward 4 diffusion})^2}{\text{diameter of perforation}^2}$

$\frac{A}{a} = \frac{\frac{\pi}{4} (d + 2\Delta)^2}{\frac{\pi}{4} d^2}$,

$\frac{A}{a} = \frac{d^2 + 4d\Delta + 4\Delta^2}{d^2}$,

$\frac{A}{a} = 1 + \frac{4\Delta}{d} + \frac{4\Delta^2}{d^2}$,

$\therefore$, as d ↑ , $\frac{A}{a}$ ↓

* Explanation developed by William Geiszler, PM-USA Research Department.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H.-3

COMPARISON OF HOLE SIZE AND HOLE NUMBER Vs.
DILUTION FOR VENTED CIGARETTES

DISTRANCE FROM MOUTH END, MM	NO. OF VENTS	DIAM. OF VENTS,MM	MEASURED DILUTION	* % INCREASE IN DILUTION	MEASURED P OF CIGT., Cm H_2O
14	2	.254	8.0	N/A	10.6
14	2	.356	8.9	11	10.2
14	2	.457	16.6	207	10.1
14	4	.254	13.1	N/A	10.2
14	4	.356	18.9	31	9.7
14	4	.457	21.4	44	9.2
14	6	.254	21.7	N/A	9.6
14	6	.356	20.6	(4)	9.7
14	6	.457	32.0	38	9.1

* Using .254 dia. as the base, with a constant number of holes

DATA FROM TENNESSEE EASTMAN COMPANY

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H.-4

HOLE SIZE Vs. HOLE NUMBER

	ABSOLUTE INCREASE	RELATIVE INCREASE
Increase from 2 to 4 holes (.254 mm)	5.1%	63.7%
2 to 6 holes (.254 mm)	13.7%	171.3%
Increase from .254 to .457 Hole Size (2 holes)	8.6%	107.5%
(4 holes)	8.3%	63.4%
(6 holes)	8.3%	38.2%

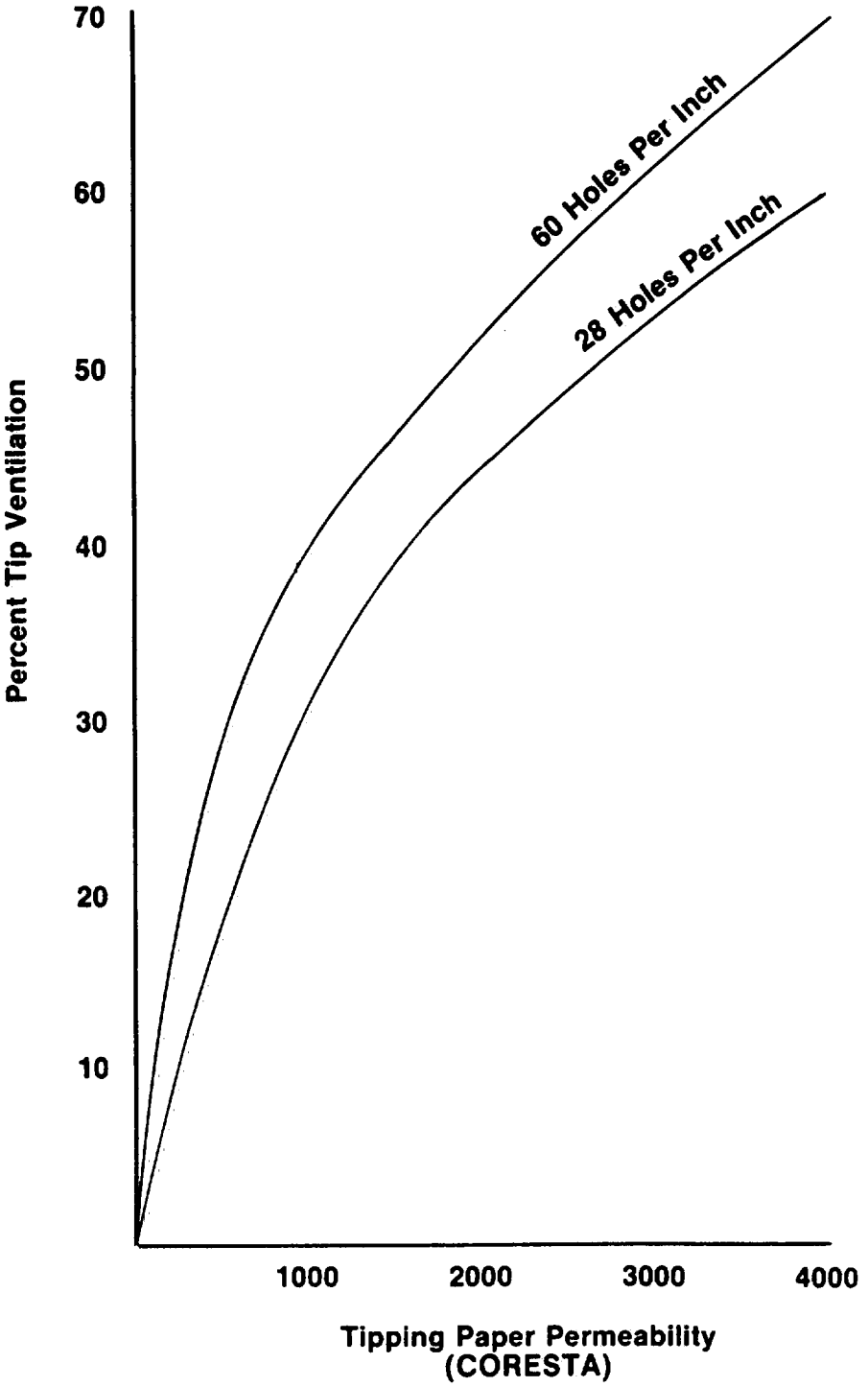
DATA FROM TENNESSEE EASTMAN COMPANY

2025455523

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

THE EFFECT OF TIPPING PAPER HOLE SIZE ON TIP VENTILATION

(Plugwrap - 26000 CORESTA)



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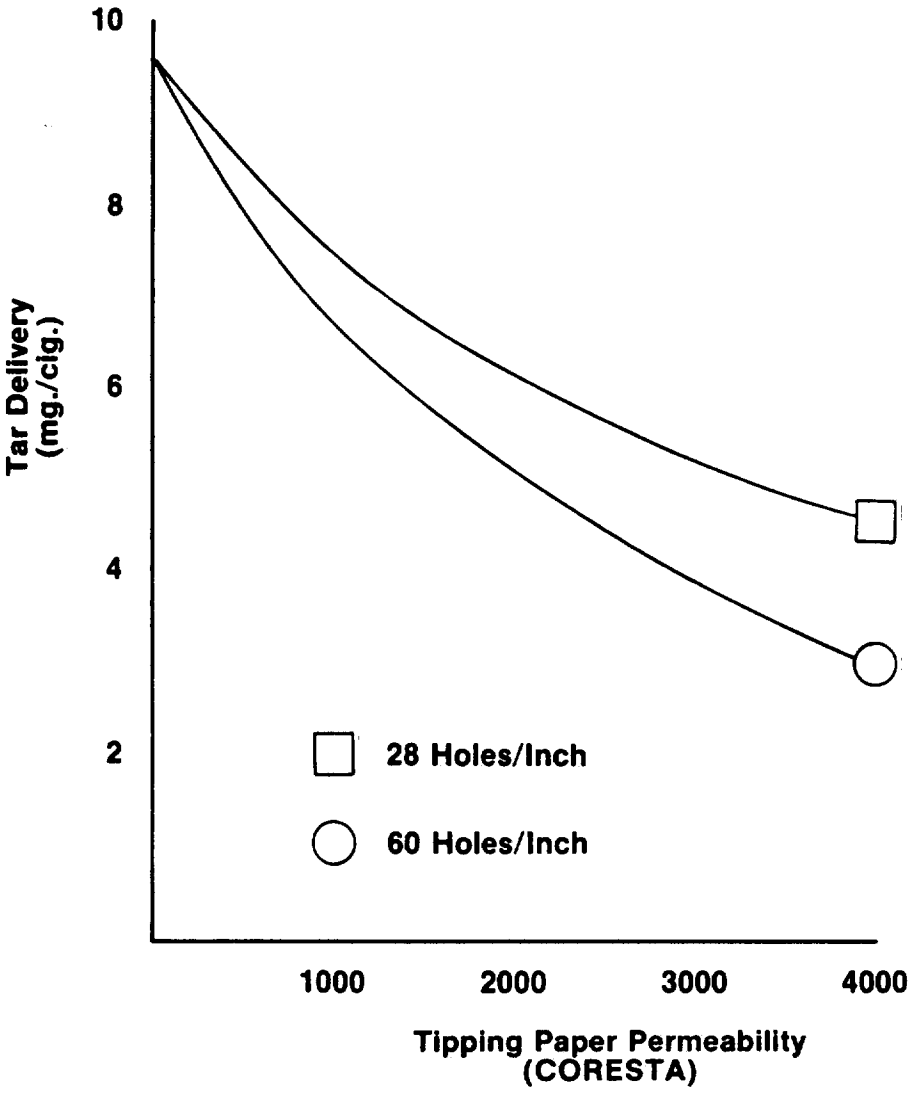
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF TIPPING PAPER HOLE SIZE ON TAR DELIVERY



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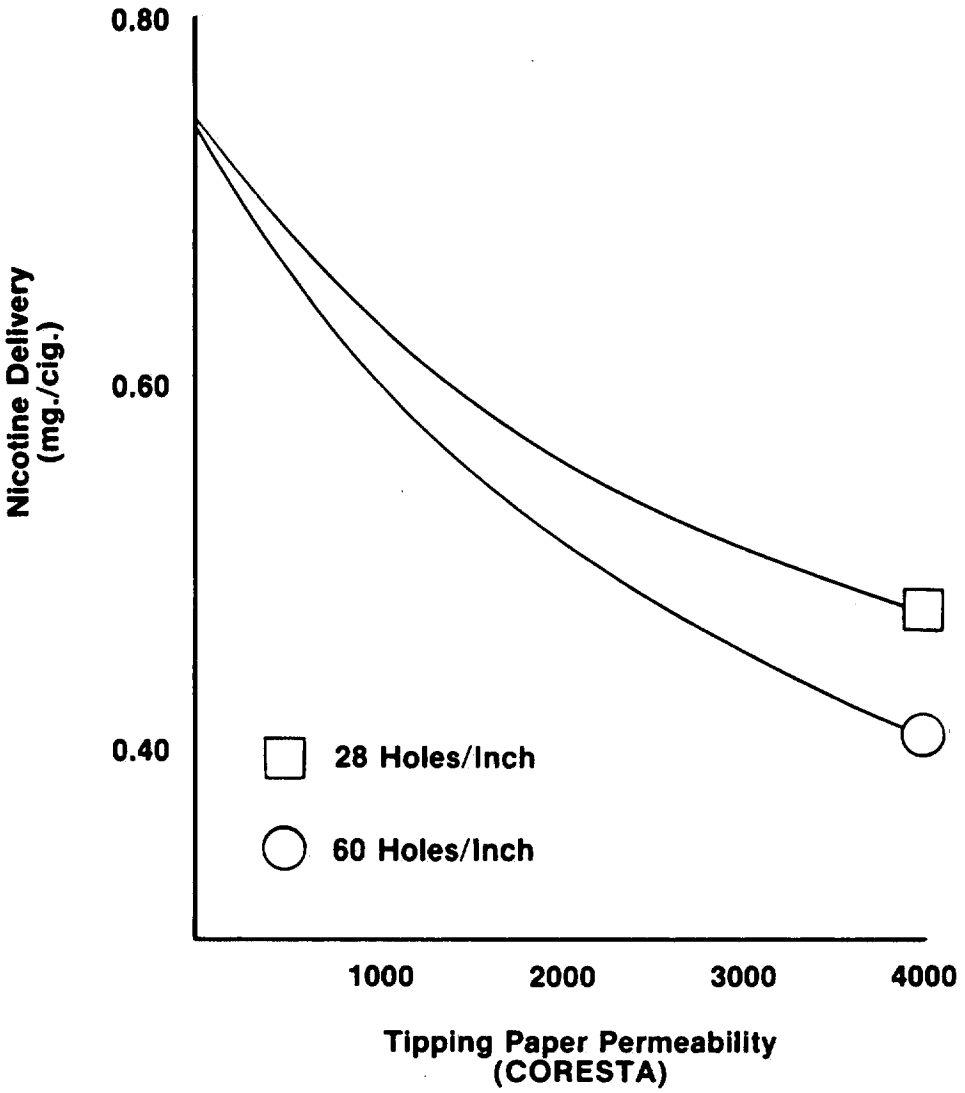
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

H.-7

EFFECT OF TIPPING PAPER HOLE SIZE ON NICOTINE DELIVERY



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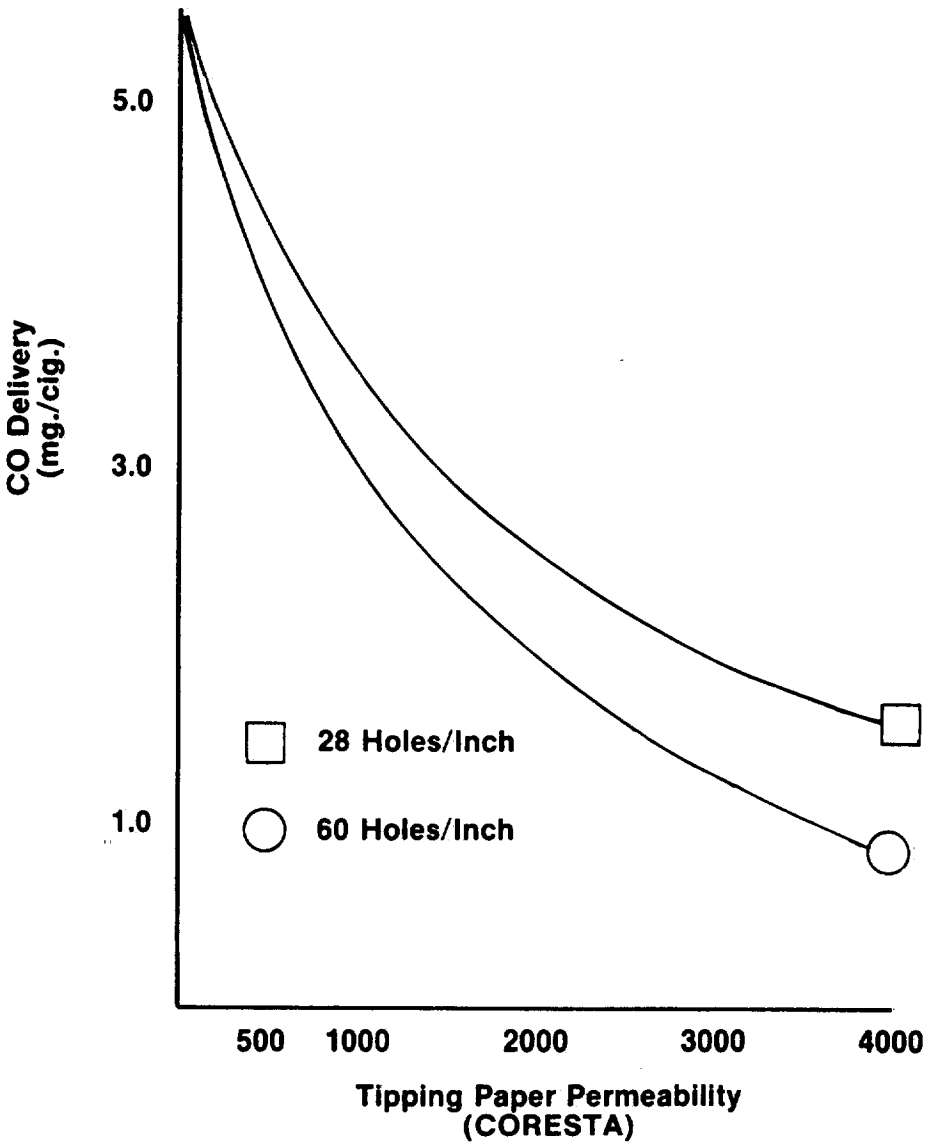
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF TIPPING PAPER HOLE SIZE ON CARBON MONOXIDE DELIVERY



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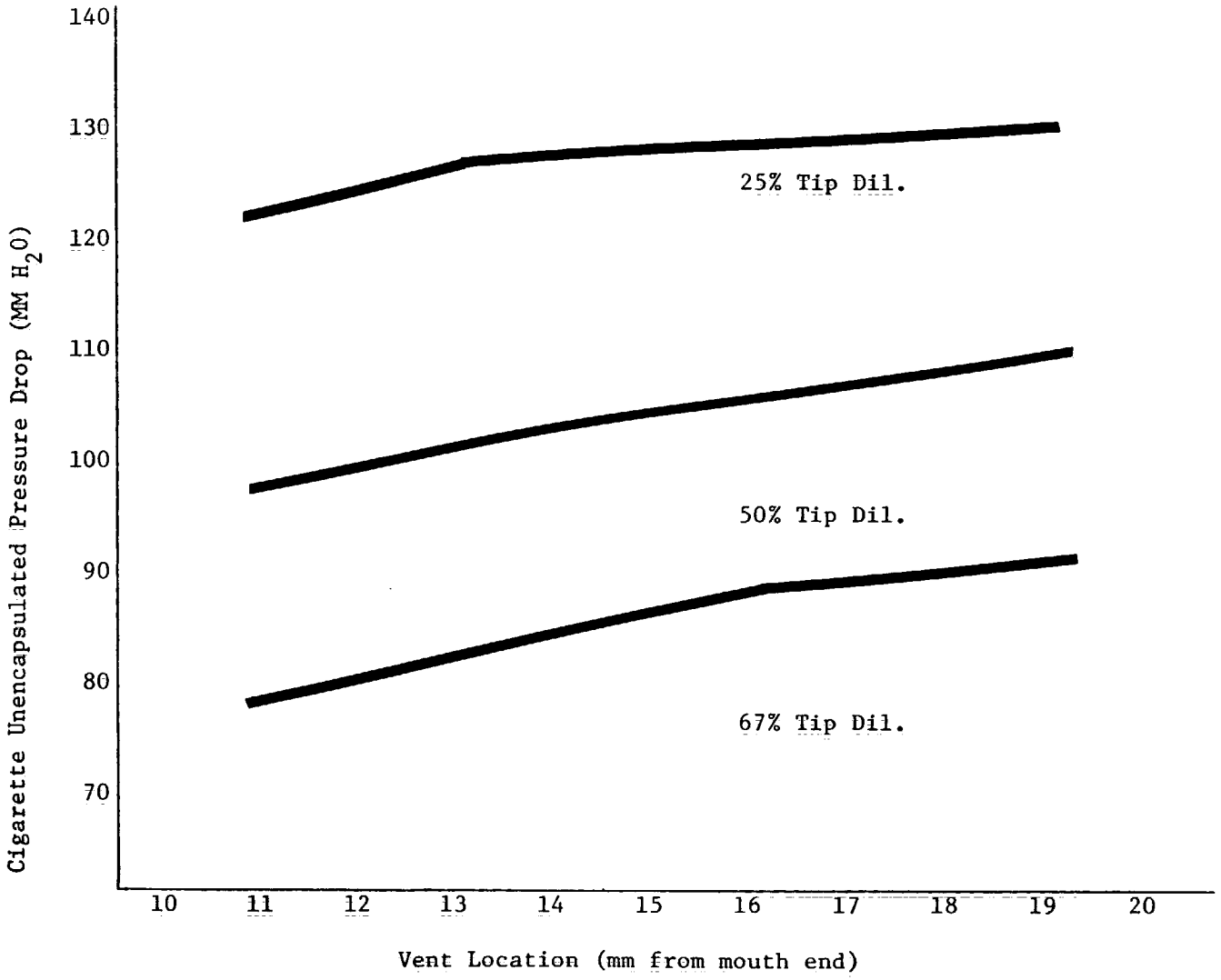
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H.-10

EFFECT OF VENTILATION HOLE LOCATION
ON UNENCAPSULATED CIGARETTE PRESSURE DROP



Data from Celanese

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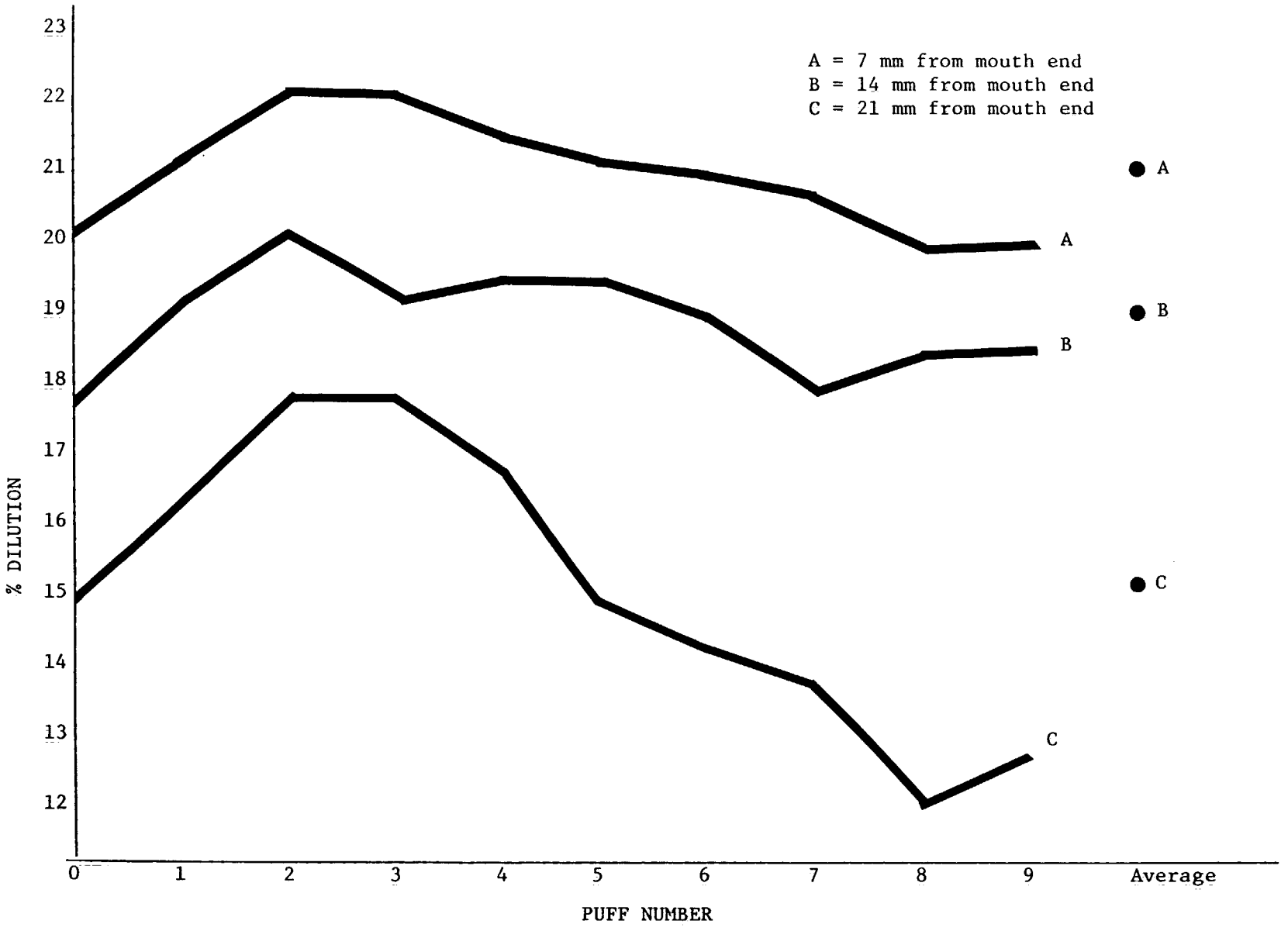
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H.-11

EFFECT OF VENT POSITION OF PER PUFF DILUTION



2025445529 Data from Tennessee Eastma Company

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H.-12

COMPARISON OF VENTILATION HOLE LOCATION Vs. TAR AND NICOTINE DELIVERIES FOR VENTED CIGARETTES

DISTANCE FROM MOUTH END, MM	NO. OF VENTS	DIAM. OF VENTS, MM	TAR DELIVERY Mg/Cigt.	PER CENT REDUCTION	AVG. %	NICOTINE DELIVERY Mg/Cigt.	PER CENT REDUCTION	AVERAGE %
7	2	.254	16.4	7.8		1.23	9.5	
7	4	.254	15.9	10.6	11.0	1.29	5.1	9.0
7	6	.254	15.2	14.6		1.19	12.5	
14	2	.254	17.3	2.8		1.35	0.7	
14	4	.254	15.7	11.7	8.0	1.23	9.5	6.1
14	6	.254	16.1	9.5		1.25	8.0	
21	2	.254	17.5	1.6		1.32	2.9	
21	4	.254	16.8	5.6	5.6	1.35	0.7	2.9
21	6	.254	16.1	9.5		1.29	5.1	

DATA FROM TENNESSEE EASTMAN COMPANY

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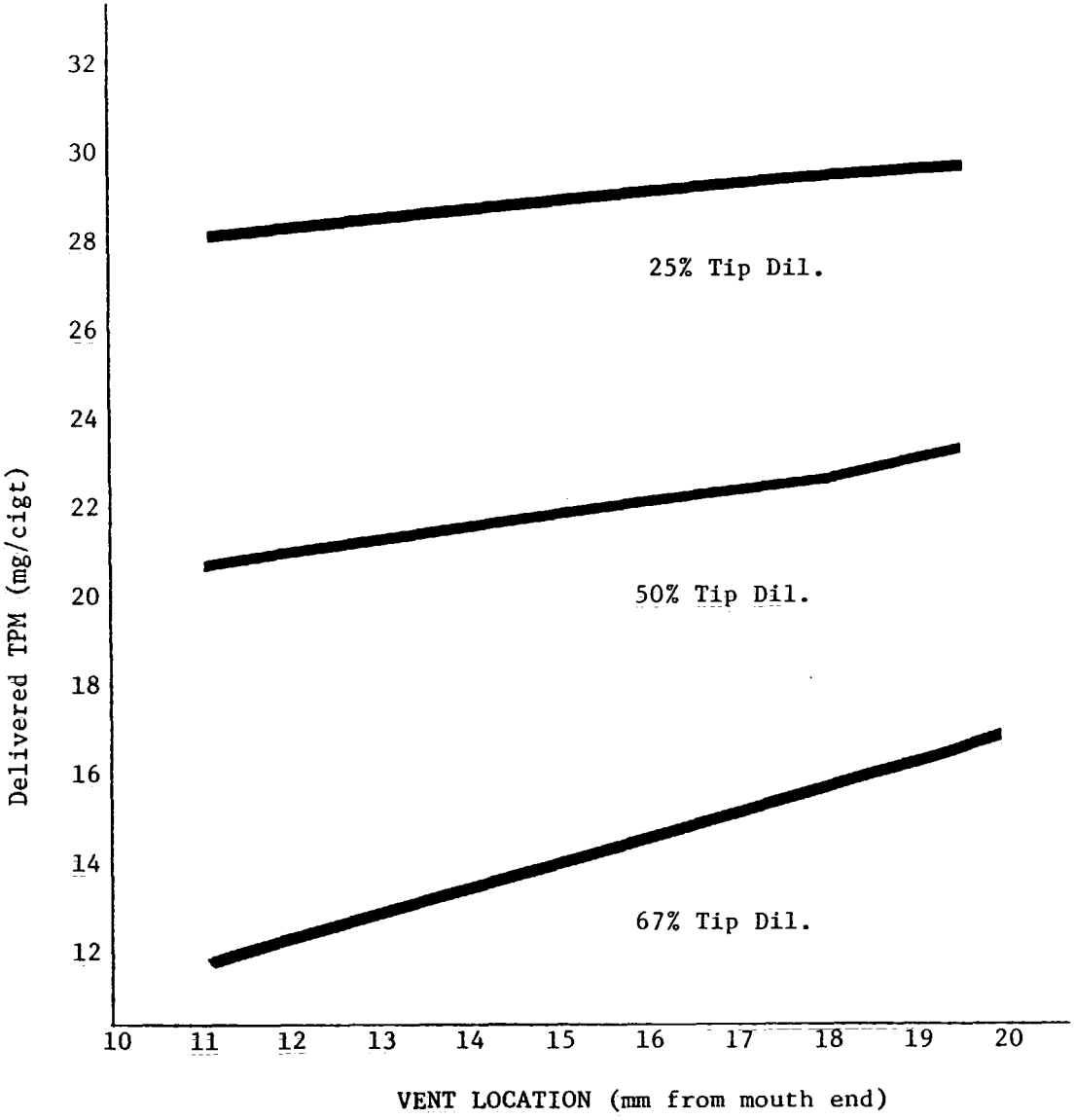
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H.-15

EFFECT ON VENTILATION HOLE LOCATION
ON TOTAL PARTICULATE MATTER DELIVERY



Data from Celanese

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

1. U.S. INDUSTRY PROFILE OF PERFORATION VARIABLE PARAMETERS

COMPANY	VENTILATION TYPE	NO.OF ROWS	START OF HOLES, MM	RANGE OF BAND WIDTH, MM	BAND RANGE FROM MOUTH END, MM	* AVG. ROW DISTANCE, MM
PHILIP MORRIS	ESP	Band	12-14	2-4	12-17	14.3
	Hauni Pin	1	11-13	NA	11-13	12.3
	On-Line Laser	1	12	N/A	12	12.0
	Laser	2-8	12-13	1-7	12-20	13.4
	Mechanical	1-5	12-13	NA-3	12-15	12.9
R.J. REYNOLDS	ESP	Band	12-15	3-5	12-20	14.4
	Laser	2	12	1	12-13	12.5
	Mechanical	1-7	12-19	NA-5	12-21	15.6
AMERICAN BRANDS	Laser	1-6	12-15	NA-10	12-22	13.5
	Mechanical	1	13	NA	13	13.0
LORRILLARD	Mechanical	1-7	12-15	NA-5	12-18	15.1
	Micro-Mechanical	Band	13	4	13-17	15.0
	Porous Tipping	NA	NA	NA	NA	NA
BROWN & WILLIAMSON	ESP	Band	13	3	13-16	14.5
	Laser	1	14	NA	14	14.0
	On-Line Laser	1	15	NA	15	15.0
	Mechanical	1-3	12-16	NA-2	12-17	15.0
LIGGETT & MYERS	Laser	1	15-16	NA	15-16	15.2
	Mechanical	1	14-15	NA	14-15	14.5

* Start of Holes Plus (Band Width ÷ 2). Note: This figure cannot be derived from the data shown in this table.

1. Actual measured Data. May not agree exactly with targets.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

I. CIGARETTE DESIGN

1. Introduction

Cigarette design is the place where all of the theoretical delivery reduction data can be tied together. Here you develop the model approximations that will be used to make the first sample cigarettes. Actual production and testing will dictate most of the specification changes needed to achieve the original targets. These changes are inevitable. No amount of design research can eliminate the necessity to refine the product in the factory. However, good cigarette design, using historical data, can minimize the number of different samples that must actually be manufactured.

The focus on cigarette design here will obviously be ventilation. The processes described within, though accurate, are a simplification of a complex subject. This is a ventilation seminar, not a cigarette design seminar. Therefore, many important parts of cigarette design have been covered superficially or not at all. Blend, tow selection, and burn rate are a few examples that come to mind. It would be possible to spend days covering these subjects alone. Instead, we have developed some hypothetical cigarette brands, using historical data, to illustrate how you can begin ventilating a full flavor 18 mg. tar cigarette and make low and ultra-low tar brand extensions. All of these calculations assume brand modifications or extensions from existing brands. The complexities of designing a cigarette from the beginning are left to others, though the same basic principles can be applied.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

There are many ways to incorporate the material presented earlier in cigarette design. You can use the mathematical ventilation model described earlier to predict dilution level. Market trends in each specific area will determine your delivery targets, cigarette and filter lengths, and total RTD. All of the alternative means for lowering deliveries should be considered before deciding upon the best solution for that time and place. Which type of cigarette paper/tipping/plugwrap to use are important variables. What effects will ventilation and ventilation variability have upon the cigarette? There are many graphs and tables you can use from the seminar to simplify the job of predicting tar delivery vs. dilution, or RTD vs. dilution, to name just a few. If you find any of this information helpful, there is no reason not to use it.

2. Design Philosophy

a. General Guidelines

Before beginning any cigarette design project, it is important to examine the company's basic design philosophy. In this case, I will be speaking about Philip Morris U.S.A.'s design philosophy. This approach is also pertinent to any Philip Morris brands, wherever they are made. Exceptions to these basic guidelines usually must be approved by the Corporate Products Committee. Each market is unique. Therefore, it is quite possible that some countries may utilize very different design philosophies for use on local brands. This option remains with individual management. None of these rules are hard and fast. Government action, consumer pressure, supplier constraints, and outright machinability problems may force you to modify some of these guidelines. The closer you can keep within the specified limits, though, the better the

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

probability for consumer acceptance of the product. These guidelines were not determined arbitrarily. Years of research and experience has led to the evolution of this format.

Figure I.-1 shows the basic guidelines used in designing cigarettes. Tar per puff is the taste factor, not total tar per cigarette. Therefore, you want to maximize that as much as possible. Keeping the puff count down within reasonable limits will help do this. We try to maintain total cigarette RTD (unencapsulated) between 4 and 5 inches (102 - 127 mm). We do have cigarettes on the market that are higher in RTD than 5 inches, but as a rule, the consumer does not readily accept cigarettes with a high pressure drop. When low tar cigarettes first developed in Canada, they utilized filtration, rather than ventilation. This brought RTD's into the 6 and 7 inch range and they were successfully marketed. Ventilation has brought them back into a more acceptable limit. In spite of the acceptance of the high RTD cigarette in Canada, it is risky to assume the pattern can be duplicated in other locations. This is especially so when technology (ventilation) is so readily available that can eliminate the problem of reducing deliveries without raising RTD to high levels.

The fourth item listed is to choose a mid-range porosity cigarette paper in order to allow room to move up or down to fine-tune the tar delivery target. Once actual test production of your new product begins, all of the interaction of variables usually causes the actual deliveries to deviate from the predicted deliveries. It will make the job of Operations Services, or whoever has the responsibility for developing new brands in production, that much easier if there is an

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

easily changed variable like cigarette paper available to modify. If you design a cigarette using 8 second paper, for example, you cannot lower deliveries any further by changing to a different cigarette paper, because you are already using a minimum opacity paper.

The last item to be considered is the tow item. It is important not to go below 1.6 DPF tow. We try to stay above 2.0 DPF. The reason for this is simply because we are unable to maintain a minimum of about .7 - .8 mm Filtrona firmness for a filter rod when denier per filament becomes very low. There are other guidelines, but these are the most important ones.

Along with the guidelines, there are basic rules of thumb we try to use in order to minimize the ability of the consumer to detect changes in an existing cigarette. You never want to rapidly implement a major design change all at one time. It is much better to do it incrementally to avoid perceived differences that may alienate your target market. Once again, these correlaries are a tabulation of experience over the years.

Figure I.-2 lays out four of the major considerations. For existing brands, don't change puff count more than 1 puff at a time. It is preferable to change puff count less than a full puff, and step it down if necessary. Changes in tar per puff less than $\pm$ 10% are not subjectively detectable. Therefore, a change in tar per puff of $\pm$ 20%, for example, should be done in at least two stages.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Do not make major filter or cigarette length changes in one step. This is better done a millimeter or fraction of a millimeter at a time. Even then, you cannot decrease total length or increase filter length much on an existing brand before the customer feels cheated. The fourth point to consider is to try and minimize perceived total RTD changes. The customer becomes used to a certain resistance to draw. You are opening the door for brand defection if you tamper very much with this parameter. You should make the necessary changes, even if it means changing tow items, in order to maintain roughly the same unencapsulated RTD.

b. Design Steps

In changing an existing brand to modify deliveries or develop a brand extension, there is a general sequence of operations that we perform to work through the cigarette design process. It will be helpful to review these steps before proceeding with the example brand modifications in order to better understand how and why changes were made.

Figure I.-3 can be used to walk through the basic cigarette design steps used at P.M. U.S.A. The first step is to determine your FTC tar target. This will be determined by market trends. You will want to hit this figure fairly closely, usually $\pm$ .5 mg. Nicotine deliveries are usually left to fall where they may, although in certain cases, such as Saudi Arabian export brands, specific nicotine targets must also be met. CO delivery is usually targeted in a broad manner only. The next steps are to choose your cigarette and filter lengths. These, too, are determined by market. Venezuela, India, and Pakistan are all

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

short (@ 70mm) cigarette markets. In this case, ventilation becomes all the more important, because you do not have the flexibility that we have in this country to manipulate filter length over a wide range in order to vary deliveries. A target cigarette RTD must then be selected. Once again, the RTD of the final product may have to be slightly changed to accomodate other factors. It should still be in the 4-5 inch range. The last parameter to be chosen before any testing is done is the cigarette paper. As mentioned earlier, it should be a mid-range porosity paper to allow for changes upwards or downwards in porosities, hence deliveries. Most of our papers have standard range citrate levels, from .6%-.9%. Higher citrate levels will increase burn rate and generally decrease deliveries.

Before proceeding any further, it is necessary to determine the total available FTC tar of the tobacco column as smoked. This is the total cigarette length minus the butt length. You should do this with the type of cigarette paper you plan to use. Yearly crop changes make it prudent to re-test any standard tobacco column blends you may use for just this purpose. It is essential to know where you are starting before you can determine how and how far you need to reduce deliveries. Any increase in butt length without a corresponding increase in cigarette length will reduce the availables.

After you know the availables, you must decide upon an approximate filter efficiency/dilution mix. That is, in order to reduce the total availables down to the target tar level, you must do it with some combination of filter efficiency and dilution. Historical

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

subjective data should help to get a starting point here. You need this information in order to proceed to the next step, which is the choice of tow item. What you are looking for is a tow item whose efficiency level, in conjunction with the dilution level, will allow you to reach your tar delivery target at the chosen RTD. The tow selected will obviously have to meet minimum firmness levels at the given RTD and length. Obviously, it will be cheaper if you can utilize tow items that are currently a part of your inventory, rather than adding new ones. Along with the tow item, you will also have to choose a plugwrap and tipping type. As we use tipping paper to control ventilation, we are in the process of consolidating plugwraps to minimize carrying costs. The plugwrap selection will therefore be fairly simple for us. Your situation may be different, depending on circumstances. Tipping paper type will depend on all the usual criterion, plus the ventilation type if the ESP method is used. Blend is also an important variable in cigarette design. However, for our purposes, we will assume the same blend is being used until the introduction of the ultra-low tar product, when the ET content will be substantially increased. You may also play around with puff count at this point to maximize tar per puff, or you may prefer to wait until test cigarettes are made to see exactly where it lies.

In our simplified design model, we are now ready to go into the factory, or pilot plant. You will want to make some cigarettes according to the specifications that you have designed. Analytical data should then be generated to see whether or not the targets have been achieved. It may turn out that you cannot reach the target pressure drop under the given constraints. You may have to adjust

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

The ventilation level or tow weight. Tar delivery may be too low, leading you to choose a less porous cigarette paper, for example, or maybe you prefer to decrease the citrate level, if it was high to start. There are many ways to adjust the initial specifications to reach the specified targets. We will only touch upon them here.

3. Hypothetical Delivery Reductions

a. Full Flavored-Unventilated to Ventilated

I will be examining three different brand modifications using ventilation on existing brands. All of them will maintain a constant 84.0 mm K.S. cigarette length. The first one will be a simple modification of an existing product. Our goal is to begin ventilating an existing full flavored brand to decrease CO deliveries 2 mg., from 18-16 mg. while decreasing tar delivery no more than 1 mg. Ventilation is the preferred method for this, because it increases the tar to CO ratio.

We chose this example for two reasons: 1) to have a reason to ventilate above 13 mg tar delivery, and 2) because we actually did this when it appeared CO deliveries may have become a major public issue. As a general rule, though, there is no reason not to use some form of increased filtration to lower tar deliveries as long as the target tar delivery is 13 mg or higher. This assumes you are currently not ventilating and would have to incur the initial capital outlay to begin ventilating. We have found here there is no subjective advantage to ventilation vs. filtration efficiency above 13 mg tar. You should not, however, extrapolate this statement to your own

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

particular market. Different tobaccos and consumer tastes may yield a preference for one method or the other, so you should conduct your own research. For your own purposes, you will probably be much more concerned with tar than CO.

Figure I.-4 shows selected cigarette C.I. - type information for our hypothetical cigarette brand. The original unventilated brand is on the left, with the modified brand on the right. We won't bother to use our design steps in this case because the only changes we made were the initiation of 10% ventilation into the cigarette and a small increase in the porosity of the cigarette paper used. The filter length and tow item were left unchanged, but the filter efficiency decreased slightly due to the 0.2 inch drop in cigarette RTD caused by the ventilation. Rather than adjusting any of the filter variables to maintain total RTD, we decided to let it drop into the mid-point of our target 4-5 inch range. It was tending to the high side before. You can check the RTD reduction vs. % Dilution graph to verify the figures.

We began the excercise with 32 mg available tar for the 56 mm tobacco column smoked (TCS). The 45% efficiency filter reduces tar to 17.6 mg. Moving to the Tar Reduction vs. % Dilution graph, we see a 10% dilution level will yield about 6% less tar. This will bring the remaining 17.6 mg tar down another mg. to 16.6 mg. tar. Consulting the Cigarette Paper Porosity vs. % Dilution graph, we see a little interpretation is in order. The 16 and 12 second papers correspond roughly to 35 and 50 CORESTA paper. There is a 35, but not a 50 CORESTA paper listed, the closest being 70 CORESTA. Taking all

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

of this into account, we see about a .3 mg tar decrease due to the paper change, leaving us with 16.3 mg. We are taking all of these tar figure targets to be ± .5 mg, leaving us with a 16 mg tar figure.

The Nicotine vs. % Dilution graph shows no reduction at 10% ventilation. The Cigarette Paper Porosity vs. % Dilution shows a negligible .02 mg reduction. Turning to the CO vs. % Dilution graph, we can see the reduction is very close to 1:1 at this point, so we get a 1.8 mg (10%) reduction from the original 18 mg. CO cigarette. The lower porosity cigarette paper will also lower CO. The CO vs. Cigarette Paper Porosity will again require the type of interpretation used earlier. This translates into about 0.4 mg. less CO, leaving us with 15.8 mg. or 16 mg. CO. We have therefore succeeded in dropping CO slightly below our target, while leaving tar slightly above our target. This was accomplished with a minimum of changes. As mentioned earlier, this is obviously a simplified case, but these excercises will give you a good starting point to develop actual test cigarettes.

b. Full Flavored to Low Tar - Both Ventilated

We move on to Figure I.-5. Here we designed a low tar "Lights" brand extension from our previous model. As you can see, the only parameter that hasn't changed is the ET content! It will be helpful to follow the design steps to develop our new brand. The first thing we need to do is establish our tar target. This we have set at 11 mg. As we will be reducing tar by almost one third, major design changes will be necessary. Our filter length is

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

increased by 6 mm. We stated in the beginning that cigarette length will remain constant. The fourth step is to choose an RTD. Let us assume we are not yet willing to drastically vary the dilution level. Therefore, we will have to put the major burden on filtration to reduce tar. Because of this, we will accept up to a 5 inch RTD target to give us more leeway in that area. It can be slightly less and we would be happy. It is still within our stated guidelines, and it is not unusual to see low tar cigarettes with higher RTD's than full flavored cigarettes. We see no need to change the cigarette paper at this point. Step 6 calls for us to determine the available FTC tar. Due to the filter length change, our available tobacco column to smoke decreases by an equal amount, or 11%. This leaves us with 28.6 mg. available tar.

Since we decided to re-design the filter, we chose to increase filter efficiency from 45% to 55%. We hope to use a dilution level in the 20% range. We now need to choose a tow item that will allow us to hit our 5.0 inch RTD target while maintaining a 55% efficiency. You must turn to capability curves to do this. The calculations won't be presented here, but you will find it is not possible to meet those criterion with the 3.3/44,000 tow on the existing model. 3.7/48,000 was found to meet the specifications. Our encapsulated filter plug RTD was 4.0 inches. The 11% decrease in tobacco column length decreased the rod RTD by an equal amount, leaving us with 1.6 inches, that makes a total RTD of 5.6 inches. If we check the RTD Reduction vs % Dilution graph, we find our target 20% dilution level will generate about a 13% reduction in RTD. This will put us at 4.9 inches, just under our 5.0 target. We are satisfied with that. The drop

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

in the length of the tobacco column was primarily responsible for the full puff drop in puff count. This will help keep the average tar per puff up.

Let's move on to tar delivery. Using our 55% filtration efficiency on the 28.6 mg available tar yields 12.9 mg. The Tar Reduction vs. % Dilution graph shows a 20% dilution level will decrease tar about 18%. This will reduce our deliveries to 10.55 mg. We are within the $\pm$ .5 mg range of our tar target, but prefer to be closer to 11 mg. A change in cigarette paper back to the old 16 second porosity paper should give us about .35 mg more tar. We end up with a total of 10.9 mg tar, right on our 11 mg target. In addition, this less porous paper will help keep the puff count from dropping too much.

Nicotine levels are dependent largely on the tow change and cannot be accurately predicted. As we stated at the beginning, nicotine levels are generally allowed to fall where they may after the first test cigarettes are made. Our CO deliveries did not fall as much as the tar did. This makes sense when you recall we relied on filtration rather than ventilation to do the majority of the tar reduction. You will remember filtration is more effective for the particulate phase than ventilation in the lower levels of ventilation, while ventilation is more effective for gas phase removals at low levels. From the charts, we see that 20% dilution will decrease CO by an equal percentage. That brings our 16 mg. CO cigarette down to 12.8 mg. The cigarette paper change we made to bring tar delivery back up will also increase CO by .4 mg, or 13.2 mg total. We now have a basic cigarette design we can use to make sample cigarettes. That first CI will be a much

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

more useful guide for necessary modifications than excessive theoretical manipulations. Once you have developed the basic design, you should proceed with the sample manufacture, then refine the design.

c. Low Tar to Ultra-Low Tar - Both Ventilated

The last model we developed is a hypothetical ultra-low tar brand extension from our low tar brand. Figure I.-6 details the changes. Beginning with our design steps again, we set the FTC tar target at 5 mg. The filter length and other dimension parameters are left unchanged. Because of the very low tar target, we will be employing a high degree of ventilation. Because of this, and a desire to return more to the mid-point of the ideal RTD range, we set the total cigarette RTD at 4.6 inches. We will keep the current 16 second cigarette paper. That will give us plenty of room to adjust the porosity up or down as needed. Contrary to what you might expect, the majority of the ultra-low tar brands made in this country use 16 second or higher cigarette paper. Total available tar is unchanged at 28.6 mg.

It is now time to choose a filtration efficiency/dilution mix. Dilution levels for 5 mg cigarettes in the U.S. typically run from 45% to 60%. We will select about 55% dilution to bring tar down and decrease CO. We'll increase the filter efficiency to 65%, because we need to decrease the particulate phase by more than one half. Now we have to see what tow item will let us reach these levels. Once again, I won't go into the capability curve analysis here, but we found it necessary to go to a lower DPF tow, 3.0/48,000, to reach our target RTD of 4.6 at a 65% filtration efficiency. The old tow, 3.7/48,000 could not meet all of these conditions and stay on the target line.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

The last item we changed was the ET content. We have not talked about blend at all in the other cigarettes, but it is difficult to talk about ultra-low tar cigarette design without including ET. Due to the ability to take a half per cent weight reduction for each per cent ET substituted, its use has become very widespread to reduce all deliveries. Accordingly, our ultra-light model has doubled its ET content, so it is now 20%. Aside from effecting deliveries, the extra ET will do several other things. RTD per unit length of the tobacco column is increased by ET. This explains the higher rod RTD portrayed. The ET will also burn faster, causing a decrease in puff count.

We are now ready to check our numbers. Our tow item will reduce the 28.6 mg available tar to 10.0 mg. Checking the Tar Reduction vs. % Dilution Chart, we find tar will be reduced 57% at 55% ventilation. This will reduce the tar to 4.3 mg, too low for our 5 mg target. Before altering the ventilation level, we should check the total cigarette RTD to see where we stand. The RTD Reduction vs. % Ventilation shows a 33% reduction in RTD. This will put us at 4.4 inches, which is also below our target. It seems evident by now we will have to decrease the ventilation to increase our RTD and tar delivery. If we move it back to 50%, the RTD reduction becomes 30%. This gives us our 4.6 inch target RTD exactly. Turning to tar reduction, 50% dilution will decrease tar by an equal amount, 50%. This cuts our remaining 10 mg tar in half, just where we want it.

The CO Reduction vs. % Dilution graph shows 50% dilution will decrease CO 60%. That will decrease the 13 mg CO all the way to 5.2 mg, in line with expected values.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

The final item to be noted is the puff count. That didn't drop quite as much as we wanted, which was a full puff decrease, so we decided to go to a cigarette paper that was slightly more porous and had a marginally higher citrate level. That gave us the decrease we wanted. This change also dropped the tar and CO deliveries. However, you will recall that as ventilation levels increase, the effect of cigarette paper porosity and citrate levels decrease. If you look at the porosity and citrate level graphs, you will find this change will only decrease tar and CO by roughly .1 to .2 mg, each. This will still leave us within our target levels. You can now make sample cigarettes to see how close our calculations have predicted actual analytical values.

4. Summary

We have quickly walked through three examples of cigarette design using ventilation. The range of these three covers all but the very low tar and very high tar filter cigarettes. These are greatly simplified models, but you will probably be surprised how close you can predict some of the cigarette parameter values by addressing only the design variables mentioned.

Most of you should be familiar with the basics of filter tow selection. We have illustrated how ventilation can be introduced to greatly extend the delivery reduction levels beyond the range of filter tow alone. In addition, this allows you to re-introduce tow flexibility into your design model. To explain: the low DPF-high Total Denier tows were necessary to decrease tar deliveries down to the low teens when used alone (ie - No Ventilation). By incorporating ventilation at different levels, you will find you can again use tow items that previously were phase out

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

at, say 16 mg tar, for example, due to their inability to reduce deliveries without overly increasing RTD.

We have also showed you how the graphs provided can be used for simple cigarette design. Tar, CO, RTD, and a host of other variables can be related to dilution level. Perhaps the most important quantity ventilation brings to cigarette design, aside from the obvious ability to penetrate the 13 mg tar barrier (at 5 inches RTD or less), is flexibility. This is the key element only ventilation can bring. Given the proper equipment, you can vary dilution level from 5% to 95%. It has already been shown you can reduce deliveries down to zero with ventilation, if that is your goal. Small changes in ventilation can bring RTD's into line, a feat often requiring a complete tow change in the past. Puff count can be manipulated up or down by ventilation.

It is important to remember just how many parameters are affected by ventilation. By this I mean when you change ventilation, you have altered a host of other variables. Make sure you examine all of these interelationships before deciding to increase ventilation to decrease tar delivery, or increase puff count, etc. We hope to have tied together the many sections discussed earlier. At minimum, you should have a better understanding of the variables that effect and are effected by ventilation, and how you can make ventilation work for your.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

$\pm$ 0.5 mm for the cigarette once it is cut. Measuring cigarettes, rather than tipping paper, also injects the eveness of the cigarette cut as a variable. Therefore, this table is only intended to be used to give you a general idea of the diversity that exists in the choice of perforation variation parameters with the U.S. industry. It is not a specifications listing. While exact comparisons are not reliable based on this data, it is safe to conclude such things as both Brown and Williamson and Liggett and Myers products have the start of their perforations about 2 mm further away than Philip Morris brands. The average row distance for American Brands is about the same as Philip Morris, but significantly less than the other four companies. Nobody uses more than a 10 mm band width, less than an 11 mm starting point, nor more than 8 rows. This is the type of information that can be derived from Table H.-16.

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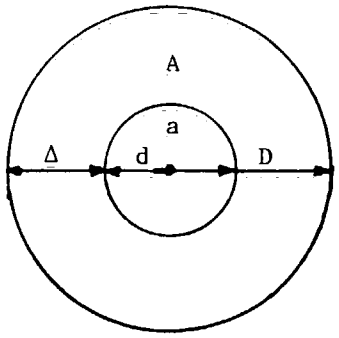
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H. 2



d = nominal diameter of perforation

D = effective diameter of perforation system

Δ = difference between radius of D and radius of d

a = nominal area of perforation

A = effective area of perforation system

* $a = \frac{\pi}{4} d^2$ $\qquad A = \frac{\pi}{4} D^2$ $\qquad D = d + 2\Delta$

$$A = \frac{\pi}{4} (d + 2\Delta)^2 ,$$

$$\frac{\text{effective area}}{\text{nominal area}} = 1 + \frac{(\text{outward 4 diffusion})}{\text{diameter of perforation}} + \frac{(\text{outward 4 diffusion})^2}{\text{diameter of perforation}^2}$$

$$\frac{A}{a} = \frac{\frac{\pi}{4} (d + 2\Delta)^2}{\frac{\pi}{4} d^2} ,$$

$$\frac{A}{a} = \frac{d^2 + 4d\Delta + 4\Delta^2}{d^2} ,$$

$$\frac{A}{a} = 1 + \frac{4\Delta}{d} + \frac{4\Delta^2}{d^2} ,$$

$\therefore$, as d $\uparrow$, $\frac{A}{a}$ $\downarrow$

* Explanation developed by William Geiszler, PM-USA Research Department.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H.-3

COMPARISON OF HOLE SIZE AND HOLE NUMBER Vs.
DILUTION FOR VENTED CIGARETTES

DISTRANCE FROM MOUTH END, MM	NO. OF VENTS	DIAM. OF VENTS,MM	MEASURED DILUTION	* % INCREASE IN DILUTION	MEASURED P OF CIGT., Cm H_2O
14	2	.254	8.0	N/A	10.6
14	2	.356	8.9	11	10.2
14	2	.457	16.6	207	10.1
14	4	.254	13.1	N/A	10.2
14	4	.356	18.9	31	9.7
14	4	.457	21.4	44	9.2
14	6	.254	21.7	N/A	9.6
14	6	.356	20.6	(4)	9.7
14	6	.457	32.0	38	9.1

* Using .254 dia. as the base, with a constant number of holes

DATA FROM TENNESSEE EASTMAN COMPANY

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H.-4

HOLE SIZE Vs. HOLE NUMBER

	ABSOLUTE INCREASE	RELATIVE INCREASE
Increase from 2 to 4 holes (.254 mm)	5.1%	63.7%
2 to 6 holes (.254 mm)	13.7%	171.3%
Increase from .254 to .457 Hole Size (2 holes)	8.6%	107.5%
(4 holes)	8.3%	63.4%
(6 holes)	8.3%	38.2%

DATA FROM TENNESSEE EASTMAN COMPANY

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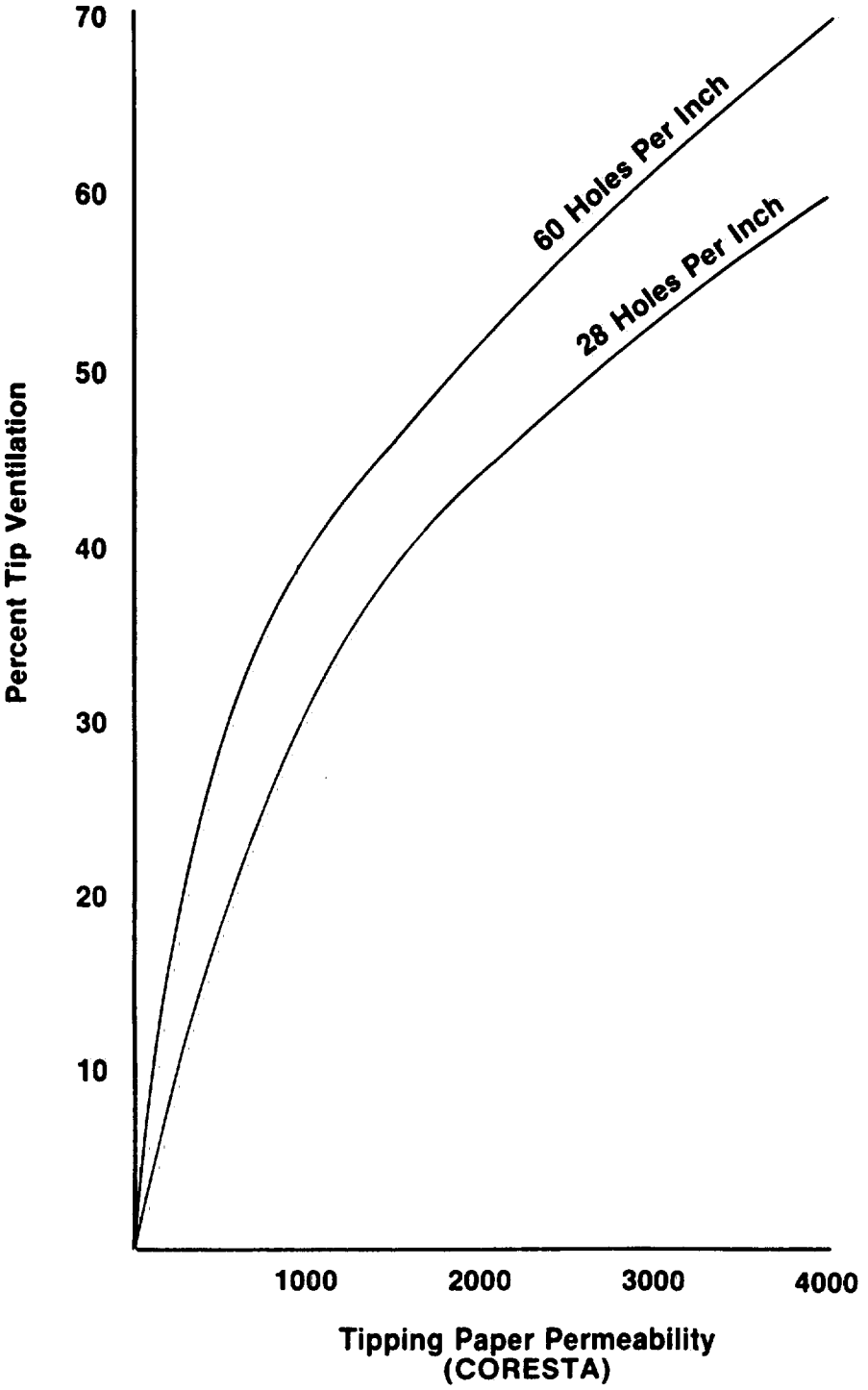
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

THE EFFECT OF TIPPING PAPER HOLE SIZE ON TIP VENTILATION

(Plugwrap - 26000 CORESTA)



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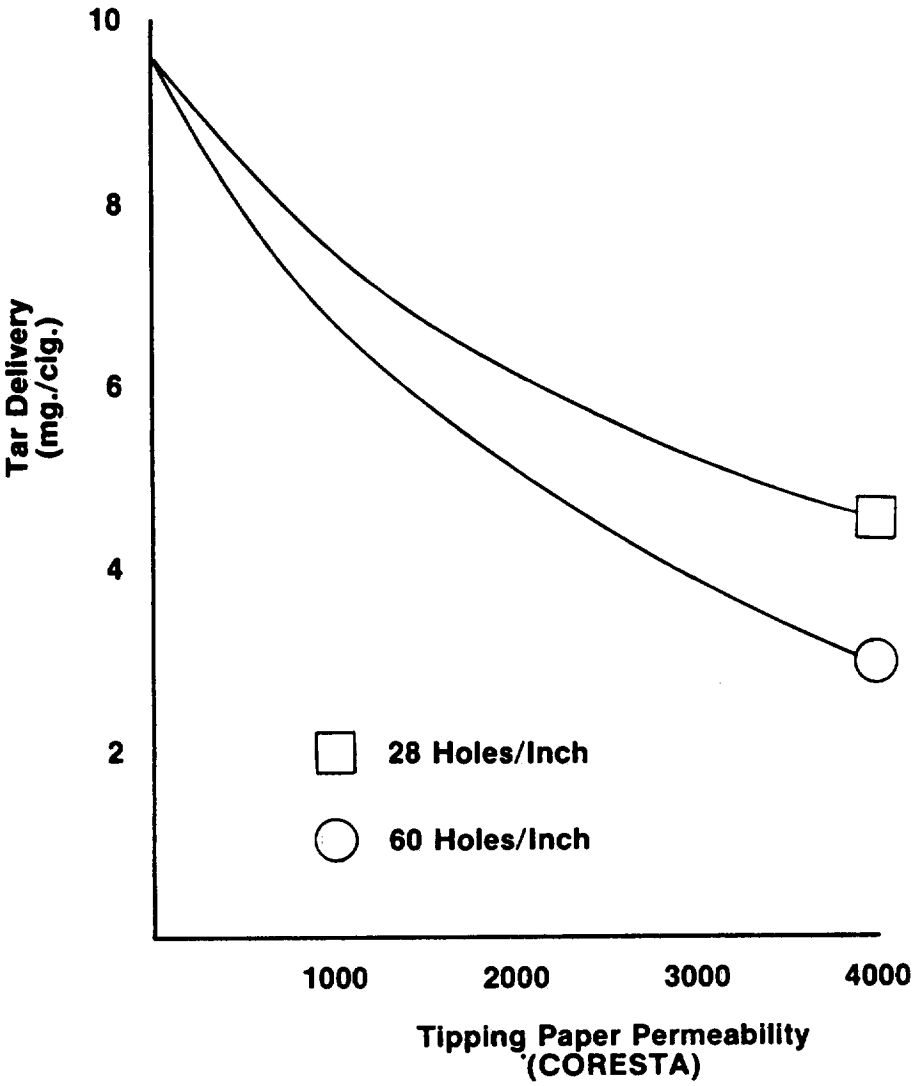
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF TIPPING PAPER HOLE SIZE ON TAR DELIVERY



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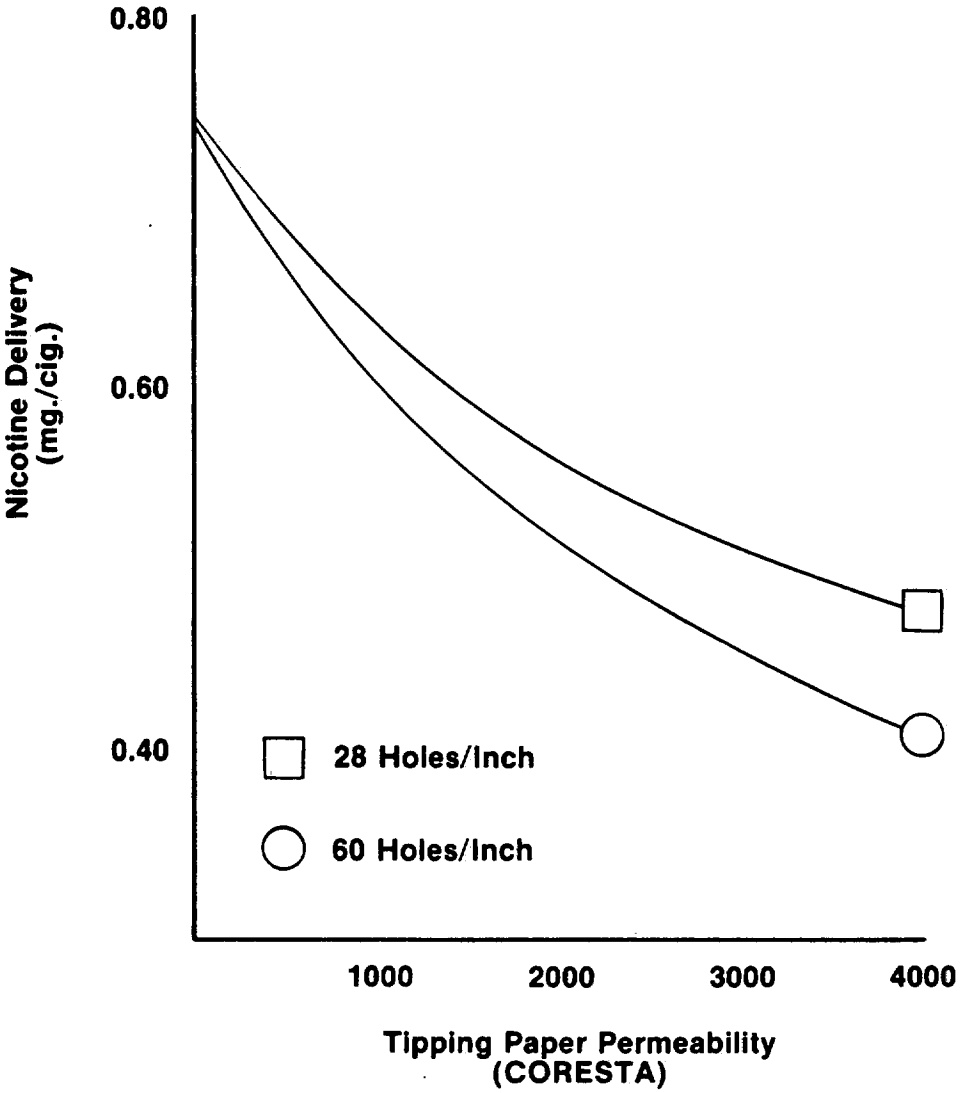
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

H.-7

EFFECT OF TIPPING PAPER HOLE SIZE ON NICOTINE DELIVERY



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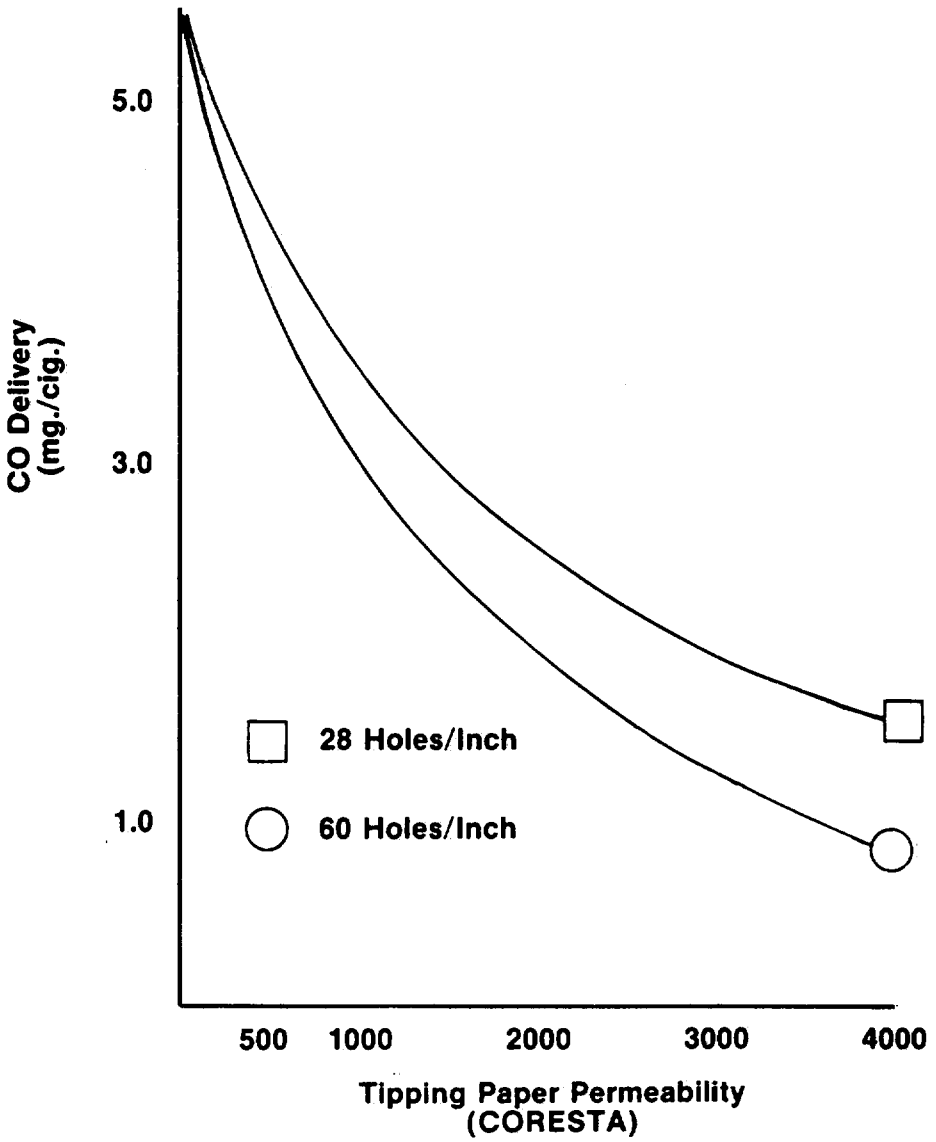
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF TIPPING PAPER HOLE SIZE ON CARBON MONOXIDE DELIVERY



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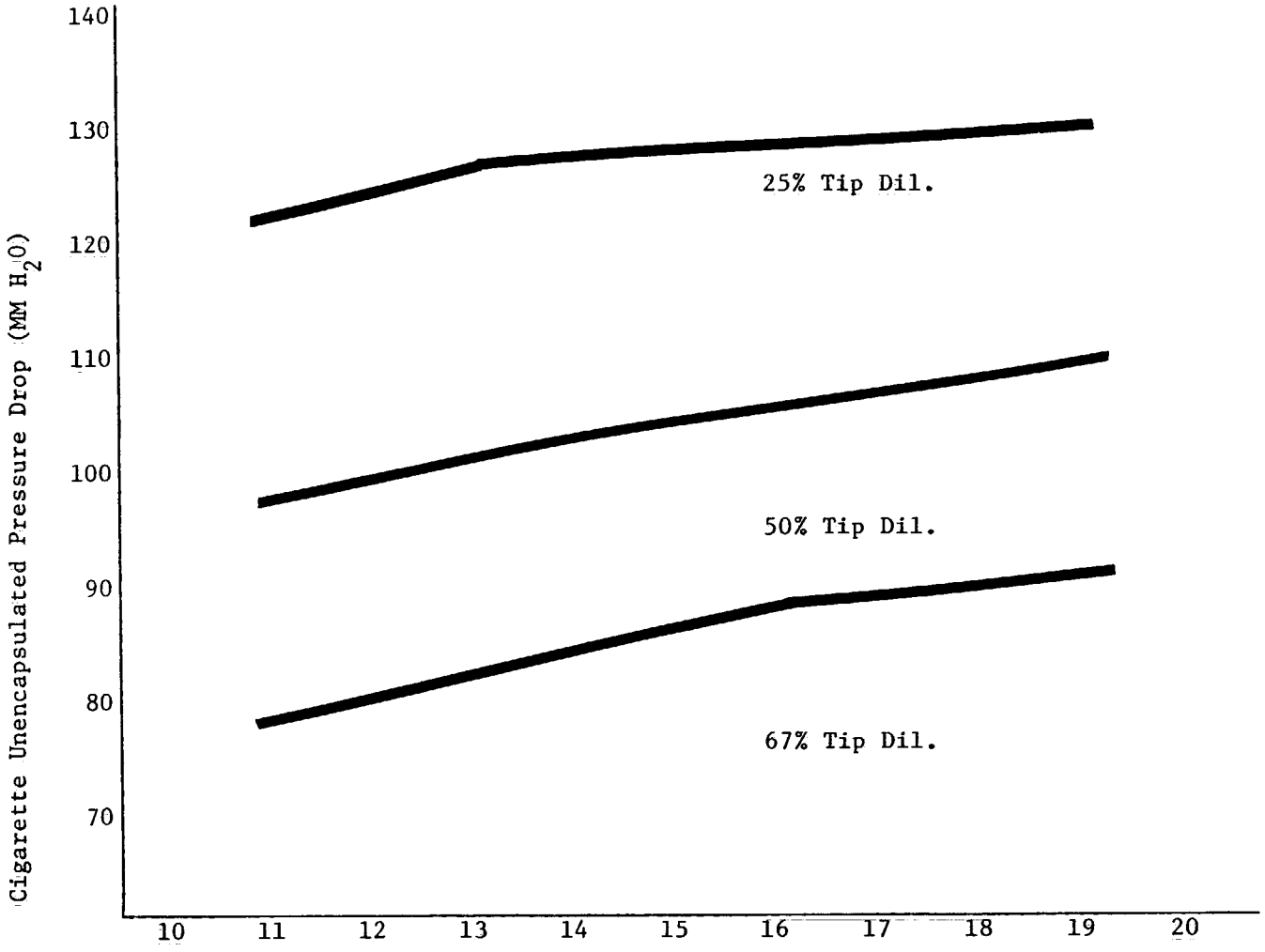
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H.-10

EFFECT OF VENTILATION HOLE LOCATION
ON UNENCAPSULATED CIGARETTE PRESSURE DROP



Data from Celanese

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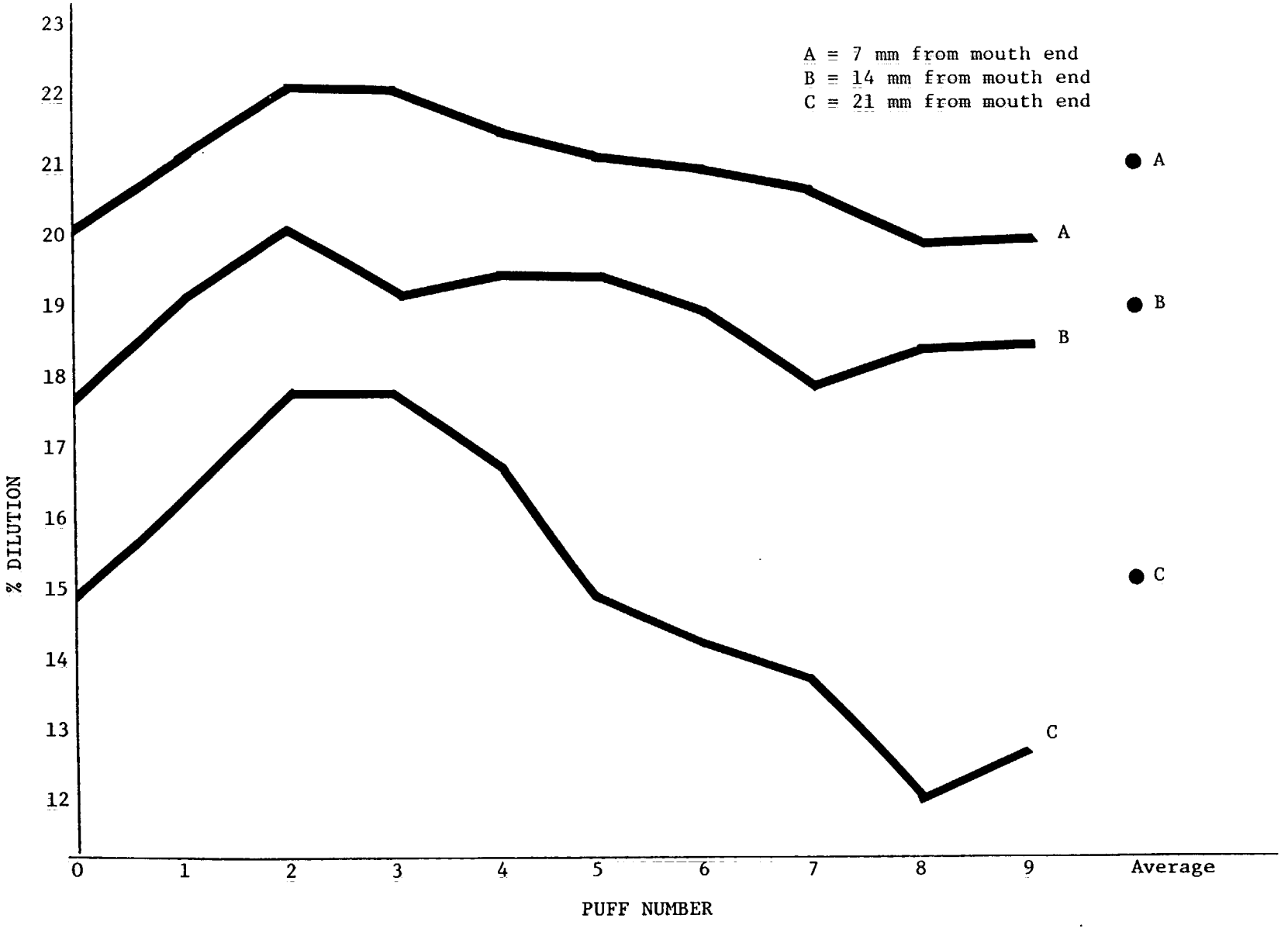
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H.-11

EFFECT OF VENT POSITION OF PER PUFF DILUTION



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Data from Tennessee Eastma ompany

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H.-12

COMPARISON OF VENTILATION HOLE LOCATION Vs.
TAR AND NICOTINE DELIVERIES FOR VENTED CIGARETTES

DISTANCE FROM MOUTH END, MM	NO. OF VENTS	DIAM. OF VENTS,MM	TAR DELIVERY Mg/Cigt.	PER CENT REDUCTION	AVG. %	NICOTINE DELIVERY Mg/Cigt.	PER CENT REDUCTION	AVERAGE %
7	2	.254	16.4	7.8		1.23	9.5	
7	4	.254	15.9	10.6	11.0	1.29	5.1	9.0
7	6	.254	15.2	14.6		1.19	12.5	
14	2	.254	17.3	2.8		1.35	0.7	
14	4	.254	15.7	11.7	8.0	1.23	9.5	6.1
14	6	.254	16.1	9.5		1.25	8.0	
21	2	.254	17.5	1.6		1.32	2.9	
21	4	.254	16.8	5.6	5.6	1.35	0.7	2.9
21	6	.254	16.1	9.5		1.29	5.1	

DATA FROM TENNESSEE EASTMAN COMPANY

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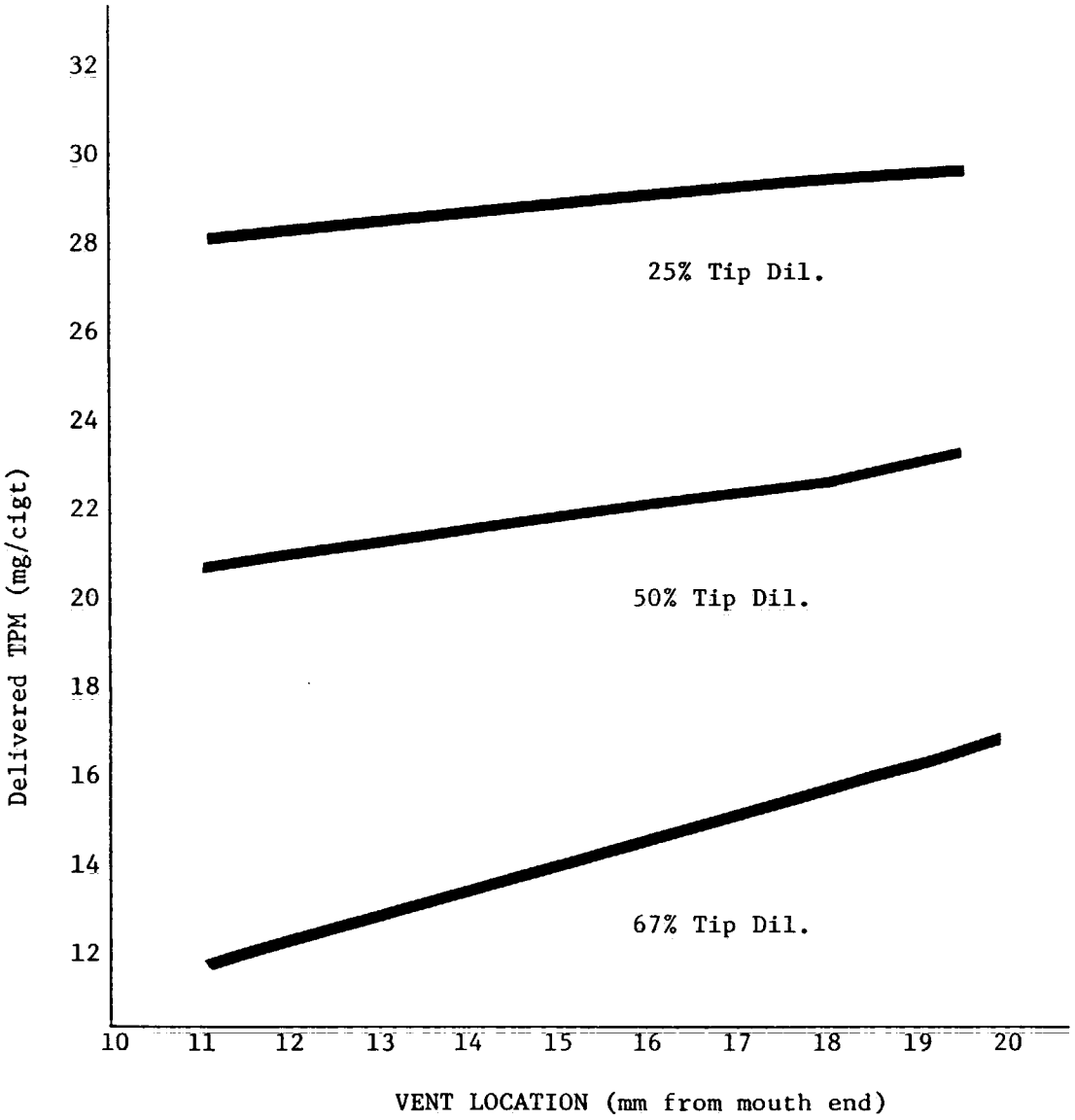
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure H.-15

EFFECT ON VENTILATION HOLE LOCATION
ON TOTAL PARTICULATE MATTER DELIVERY



Data from Celanese

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

1. U.S. INDUSTRY PROFILE OF PERFORATION VARIABLE PARAMETERS

COMPANY	VENTILATION TYPE	NO.OF ROWS	START OF HOLES, MM	RANGE OF BAND WIDTH, MM	BAND RANGE FROM MOUTH END, MM	* AVG. ROW DISTANCE, MM
PHILIP MORRIS	ESP	Band	12-14	2-4	12-17	14.3
	Hauni Pin	1	11-13	NA	11-13	12.3
	On-Line Laser	1	12	N/A	12	12.0
	Laser	2-8	12-13	1-7	12-20	13.4
	Mechanical	1-5	12-13	NA-3	12-15	12.9
R.J. REYNOLDS	ESP	Band	12-15	3-5	12-20	14.4
	Laser	2	12	1	12-13	12.5
	Mechanical	1-7	12-19	NA-5	12-21	15.6
AMERICAN BRANDS	Laser	1-6	12-15	NA-10	12-22	13.5
	Mechanical	1	13	NA	13	13.0
LORRILLARD	Mechanical	1-7	12-15	NA-5	12-18	15.1
	Micro-Mechanical	Band	13	4	13-17	15.0
	Porous Tipping	NA	NA	NA	NA	NA
BROWN & WILLIAMSON	ESP	Band	13	3	13-16	14.5
	Laser	1	14	NA	14	14.0
	On-Line Laser	1	15	NA	15	15.0
	Mechanical	1-3	12-16	NA-2	12-17	15.0
LIGGETT & MYERS	Laser	1	15-16	NA	15-16	15.2
	Mechanical	1	14-15	NA	14-15	14.5

* Start of Holes Plus (Band Width ÷ 2). Note: This figure cannot be derived from the data shown in this table.

1. Actual measured Data. May not agree exactly with targets.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

I. Cigarette Design

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

I. CIGARETTE DESIGN

1. Introduction

Cigarette design is the place where all of the theoretical delivery reduction data can be tied together. Here you develop the model approximations that will be used to make the first sample cigarettes. Actual production and testing will dictate most of the specification changes needed to achieve the original targets. These changes are inevitable. No amount of design research can eliminate the necessity to refine the product in the factory. However, good cigarette design, using historical data, can minimize the number of different samples that must actually be manufactured.

The focus on cigarette design here will obviously be ventilation. The processes described within, though accurate, are a simplification of a complex subject. This is a ventilation seminar, not a cigarette design seminar. Therefore, many important parts of cigarette design have been covered superficially or not at all. Blend, tow selection, and burn rate are a few examples that come to mind. It would be possible to spend days covering these subjects alone. Instead, we have developed some hypothetical cigarette brands, using historical data, to illustrate how you can begin ventilating a full flavor 18 mg. tar cigarette and make low and ultra-low tar brand extensions. All of these calculations assume brand modifications or extensions from existing brands. The complexities of designing a cigarette from the beginning are left to others, though the same basic principles can be applied.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

There are many ways to incorporate the material presented earlier in cigarette design. You can use the mathematical ventilation model described earlier to predict dilution level. Market trends in each specific area will determine your delivery targets, cigarette and filter lengths, and total RTD. All of the alternative means for lowering deliveries should be considered before deciding upon the best solution for that time and place. Which type of cigarette paper/tipping/plugwrap to use are important variables. What effects will ventilation and ventilation variability have upon the cigarette? There are many graphs and tables you can use from the seminar to simplify the job of predicting tar delivery vs. dilution, or RTD vs. dilution, to name just a few. If you find any of this information helpful, there is no reason not to use it.

2. Design Philosophy

a. General Guidelines

Before beginning any cigarette design project, it is important to examine the company's basic design philosophy. In this case, I will be speaking about Philip Morris U.S.A.'s design philosophy. This approach is also pertinent to any Philip Morris brands, wherever they are made. Exceptions to these basic guidelines usually must be approved by the Corporate Products Committee. Each market is unique. Therefore, it is quite possible that some countries may utilize very different design philosophies for use on local brands. This option remains with individual management. None of these rules are hard and fast. Government action, consumer pressure, supplier constraints, and outright machinability problems may force you to modify some of these guidelines. The closer you can keep within the specified limits, though, the better the

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probability for consumer acceptance of the product. These guidelines were not determined arbitrarily. Years of research and experience has led to the evolution of this format.

Figure I.-1 shows the basic guidelines used in designing cigarettes. Tar per puff is the taste factor, not total tar per cigarette. Therefore, you want to maximize that as much as possible. Keeping the puff count down within reasonable limits will help do this. We try to maintain total cigarette RTD (unencapsulated) between 4 and 5 inches (102 - 127 mm). We do have cigarettes on the market that are higher in RTD than 5 inches, but as a rule, the consumer does not readily accept cigarettes with a high pressure drop. When low tar cigarettes first developed in Canada, they utilized filtration, rather than ventilation. This brought RTD's into the 6 and 7 inch range and they were successfully marketed. Ventilation has brought them back into a more acceptable limit. In spite of the acceptance of the high RTD cigarette in Canada, it is risky to assume the pattern can be duplicated in other locations. This is especially so when technology (ventilation) is so readily available that can eliminate the problem of reducing deliveries without raising RTD to high levels.

The fourth item listed is to choose a mid-range porosity cigarette paper in order to allow room to move up or down to fine-tune the tar delivery target. Once actual test production of your new product begins, all of the interaction of variables usually causes the actual deliveries to deviate from the predicted deliveries. It will make the job of Operations Services, or whoever has the responsibility for developing new brands in production, that much easier if there is an

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easily changed variable like cigarette paper available to modify. If you design a cigarette using 8 second paper, for example, you cannot lower deliveries any further by changing to a different cigarette paper, because you are already using a minimum opacity paper.

The last item to be considered is the tow item. It is important not to go below 1.6 DPF tow. We try to stay above 2.0 DPF. The reason for this is simply because we are unable to maintain a minimum of about .7 - .8 mm Filtrona firmness for a filter rod when denier per filament becomes very low. There are other guidelines, but these are the most important ones.

Along with the guidelines, there are basic rules of thumb we try to use in order to minimize the ability of the consumer to detect changes in an existing cigarette. You never want to rapidly implement a major design change all at one time. It is much better to do it incrementally to avoid perceived differences that may alienate your target market. Once again, these correlaries are a tabulation of experience over the years.

Figure I.-2 lays out four of the major considerations. For existing brands, don't change puff count more than 1 puff at a time. It is preferable to change puff count less than a full puff, and step it down if necessary. Changes in tar per puff less than $\pm$ 10% are not subjectively detectable. Therefore, a change in tar per puff of $\pm$ 20%, for example, should be done in at least two stages.

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Do not make major filter or cigarette length changes in one step. This is better done a millimeter or fraction of a millimeter at a time. Even then, you cannot decrease total length or increase filter length much on an existing brand before the customer feels cheated. The fourth point to consider is to try and minimize perceived total RTD changes. The customer becomes used to a certain resistance to draw. You are opening the door for brand defection if you tamper very much with this parameter. You should make the necessary changes, even if it means changing tow items, in order to maintain roughly the same unencapsulated RTD.

b. Design Steps

In changing an existing brand to modify deliveries or develop a brand extension, there is a general sequence of operations that we perform to work through the cigarette design process. It will be helpful to review these steps before proceeding with the example brand modifications in order to better understand how and why changes were made.

Figure I.-3 can be used to walk through the basic cigarette design steps used at P.M. U.S.A. The first step is to determine your FTC tar target. This will be determined by market trends. You will want to hit this figure fairly closely, usually $\pm$ .5 mg. Nicotine deliveries are usually left to fall where they may, although in certain cases, such as Saudi Arabian export brands, specific nicotine targets must also be met. CO delivery is usually targeted in a broad manner only. The next steps are to choose your cigarette and filter lengths. These, too, are determined by market. Venezuela, India, and Pakistan are all

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short (@ 70mm) cigarette markets. In this case, ventilation becomes all the more important, because you do not have the flexibility that we have in this country to manipulate filter length over a wide range in order to vary deliveries. A target cigarette RTD must then be selected. Once again, the RTD of the final product may have to be slightly changed to accomodate other factors. It should still be in the 4-5 inch range. The last parameter to be chosen before any testing is done is the cigarette paper. As mentioned earlier, it should be a mid-range porosity paper to allow for changes upwards or downwards in porosities, hence deliveries. Most of our papers have standard range citrate levels, from .6%-.9%. Higher citrate levels will increase burn rate and generally decrease deliveries.

Before proceeding any further, it is necessary to determine the total available FTC tar of the tobacco column as smoked. This is the total cigarette length minus the butt length. You should do this with the type of cigarette paper you plan to use. Yearly crop changes make it prudent to re-test any standard tobacco column blends you may use for just this purpose. It is essential to know where you are starting before you can determine how and how far you need to reduce deliveries. Any increase in butt length without a corresponding increase in cigarette length will reduce the availables.

After you know the availables, you must decide upon an approximate filter efficiency/dilution mix. That is, in order to reduce the total availables down to the target tar level, you must do it with some combination of filter efficiency and dilution. Historical

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subjective data should help to get a starting point here. You need this information in order to proceed to the next step, which is the choice of tow item. What you are looking for is a tow item whose efficiency level, in conjunction with the dilution level, will allow you to reach your tar delivery target at the chosen RTD. The tow selected will obviously have to meet minimum firmness levels at the given RTD and length. Obviously, it will be cheaper if you can utilize tow items that are currently a part of your inventory, rather than adding new ones. Along with the tow item, you will also have to choose a plugwrap and tipping type. As we use tipping paper to control ventilation, we are in the process of consolidating plugwraps to minimize carrying costs. The plugwrap selection will therefore be fairly simple for us. Your situation may be different, depending on circumstances. Tipping paper type will depend on all the usual criterion, plus the ventilation type if the ESP method is used. Blend is also an important variable in cigarette design. However, for our purposes, we will assume the same blend is being used until the introduction of the ultra-low tar product, when the ET content will be substantially increased. You may also play around with puff count at this point to maximize tar per puff, or you may prefer to wait until test cigarettes are made to see exactly where it lies.

In our simplified design model, we are now ready to go into the factory, or pilot plant. You will want to make some cigarettes according to the specifications that you have designed. Analytical data should then be generated to see whether or not the targets have been achieved. It may turn out that you cannot reach the target pressure drop under the given constraints. You may have to adjust

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The ventilation level or tow weight. Tar delivery may be too low, leading you to choose a less porous cigarette paper, for example, or maybe you prefer to decrease the citrate level, if it was high to start. There are many ways to adjust the initial specifications to reach the specified targets. We will only touch upon them here.

3. Hypothetical Delivery Reductions

a. Full Flavored-Unventilated to Ventilated

I will be examining three different brand modifications using ventilation on existing brands. All of them will maintain a constant 84.0 mm K.S. cigarette length. The first one will be a simple modification of an existing product. Our goal is to begin ventilating an existing full flavored brand to decrease CO deliveries 2 mg., from 18-16 mg. while decreasing tar delivery no more than 1 mg. Ventilation is the preferred method for this, because it increases the tar to CO ratio.

We chose this example for two reasons: 1) to have a reason to ventilate above 13 mg tar delivery, and 2) because we actually did this when it appeared CO deliveries may have become a major public issue. As a general rule, though, there is no reason not to use some form of increased filtration to lower tar deliveries as long as the target tar delivery is 13 mg or higher. This assumes you are currently not ventilating and would have to incur the initial capital outlay to begin ventilating. We have found here there is no subjective advantage to ventilation vs. filtration efficiency above 13 mg tar. You should not, however, extrapolate this statement to your own

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particular market. Different tobaccos and consumer tastes may yield a preference for one method or the other, so you should conduct your own research. For your own purposes, you will probably be much more concerned with tar than CO.

Figure I.-4 shows selected cigarette C.I. - type information for our hypothetical cigarette brand. The original unventilated brand is on the left, with the modified brand on the right. We won't bother to use our design steps in this case because the only changes we made were the initiation of 10% ventilation into the cigarette and a small increase in the porosity of the cigarette paper used. The filter length and tow item were left unchanged, but the filter efficiency decreased slightly due to the 0.2 inch drop in cigarette RTD caused by the ventilation. Rather than adjusting any of the filter variables to maintain total RTD, we decided to let it drop into the mid-point of our target 4-5 inch range. It was tending to the high side before. You can check the RTD reduction vs. % Dilution graph to verify the figures.

We began the excercise with 32 mg available tar for the 56 mm tobacco column smoked (TCS). The 45% efficiency filter reduces tar to 17.6 mg. Moving to the Tar Reduction vs. % Dilution graph, we see a 10% dilution level will yield about 6% less tar. This will bring the remaining 17.6 mg tar down another mg. to 16.6 mg. tar. Consulting the Cigarette Paper Porosity vs. % Dilution graph, we see a little interpretation is in order. The 16 and 12 second papers correspond roughly to 35 and 50 CORESTA paper. There is a 35, but not a 50 CORESTA paper listed, the closest being 70 CORESTA. Taking all

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of this into account, we see about a .3 mg tar decrease due to the paper change, leaving us with 16.3 mg. We are taking all of these tar figure targets to be ± .5 mg, leaving us with a 16 mg tar figure.

The Nicotine vs. % Dilution graph shows no reduction at 10% ventilation. The Cigarette Paper Porosity vs. % Dilution shows a negligible .02 mg reduction. Turning to the CO vs. % Dilution graph, we can see the reduction is very close to 1:1 at this point, so we get a 1.8 mg (10%) reduction from the original 18 mg. CO cigarette. The lower porosity cigarette paper will also lower CO. The CO vs. Cigarette Paper Porosity will again require the type of interpretation used earlier. This translates into about 0.4 mg. less CO, leaving us with 15.8 mg. or 16 mg. CO. We have therefore succeeded in dropping CO slightly below our target, while leaving tar slightly above our target. This was accomplished with a minimum of changes. As mentioned earlier, this is obviously a simplified case, but these excercises will give you a good starting point to develop actual test cigarettes.

b. Full Flavored to Low Tar - Both Ventilated

We move on to Figure I.-5. Here we designed a low tar "Lights" brand extension from our previous model. As you can see, the only parameter that hasn't changed is the ET content! It will be helpful to follow the design steps to develop our new brand. The first thing we need to do is establish our tar target. This we have set at 11 mg. As we will be reducing tar by almost one third, major design changes will be necessary. Our filter length is

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increased by 6 mm. We stated in the beginning that cigarette length will remain constant. The fourth step is to choose an RTD. Let us assume we are not yet willing to drastically vary the dilution level. Therefore, we will have to put the major burden on filtration to reduce tar. Because of this, we will accept up to a 5 inch RTD target to give us more leeway in that area. It can be slightly less and we would be happy. It is still within our stated guidelines, and it is not unusual to see low tar cigarettes with higher RTD's than full flavored cigarettes. We see no need to change the cigarette paper at this point. Step 6 calls for us to determine the available FTC tar. Due to the filter length change, our available tobacco column to smoke decreases by an equal amount, or 11%. This leaves us with 28.6 mg. available tar.

Since we decided to re-design the filter, we chose to increase filter efficiency from 45% to 55%. We hope to use a dilution level in the 20% range. We now need to choose a tow item that will allow us to hit our 5.0 inch RTD target while maintaining a 55% efficiency. You must turn to capability curves to do this. The calculations won't be presented here, but you will find it is not possible to meet those criterion with the 3.3/44,000 tow on the existing model. 3.7/48,000 was found to meet the specifications. Our encapsulated filter plug RTD was 4.0 inches. The 11% decrease in tobacco column length decreased the rod RTD by an equal amount, leaving us with 1.6 inches, that makes a total RTD of 5.6 inches. If we check the RTD Reduction vs % Dilution graph, we find our target 20% dilution level will generate about a 13% reduction in RTD. This will put us at 4.9 inches, just under our 5.0 target. We are satisfied with that. The drop

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in the length of the tobacco column was primarily responsible for the full puff drop in puff count. This will help keep the average tar per puff up.

Let's move on to tar delivery. Using our 55% filtration efficiency on the 28.6 mg available tar yields 12.9 mg. The Tar Reduction vs. % Dilution graph shows a 20% dilution level will decrease tar about 18%. This will reduce our deliveries to 10.55 mg. We are within the $\pm$ .5 mg range of our tar target, but prefer to be closer to 11 mg. A change in cigarette paper back to the old 16 second porosity paper should give us about .35 mg more tar. We end up with a total of 10.9 mg tar, right on our 11 mg target. In addition, this less porous paper will help keep the puff count from dropping too much.

Nicotine levels are dependent largely on the tow change and cannot be accurately predicted. As we stated at the beginning, nicotine levels are generally allowed to fall where they may after the first test cigarettes are made. Our CO deliveries did not fall as much as the tar did. This makes sense when you recall we relied on filtration rather than ventilation to do the majority of the tar reduction. You will remember filtration is more effective for the particulate phase than ventilation in the lower levels of ventilation, while ventilation is more effective for gas phase removals at low levels. From the charts, we see that 20% dilution will decrease CO by an equal percentage. That brings our 16 mg. CO cigarette down to 12.8 mg. The cigarette paper change we made to bring tar delivery back up will also increase CO by .4 mg, or 13.2 mg total. We now have a basic cigarette design we can use to make sample cigarettes. That first CI will be a much

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more useful guide for necessary modifications than excessive theoretical manipulations. Once you have developed the basic design, you should proceed with the sample manufacture, then refine the design.

c. Low Tar to Ultra-Low Tar - Both Ventilated

The last model we developed is a hypothetical ultra-low tar brand extension from our low tar brand. Figure I.-6 details the changes. Beginning with our design steps again, we set the FTC tar target at 5 mg. The filter length and other dimension parameters are left unchanged. Because of the very low tar target, we will be employing a high degree of ventilation. Because of this, and a desire to return more to the mid-point of the ideal RTD range, we set the total cigarette RTD at 4.6 inches. We will keep the current 16 second cigarette paper. That will give us plenty of room to adjust the porosity up or down as needed. Contrary to what you might expect, the majority of the ultra-low tar brands made in this country use 16 second or higher cigarette paper. Total available tar is unchanged at 28.6 mg.

It is now time to choose a filtration efficiency/dilution mix. Dilution levels for 5 mg cigarettes in the U.S. typically run from 45% to 60%. We will select about 55% dilution to bring tar down and decrease CO. We'll increase the filter efficiency to 65%, because we need to decrease the particulate phase by more than one half. Now we have to see what tow item will let us reach these levels. Once again, I won't go into the capability curve analysis here, but we found it necessary to go to a lower DPF tow, 3.0/48,000, to reach our target RTD of 4.6 at a 65% filtration efficiency. The old tow, 3.7/48,000 could not meet all of these conditions and stay on the target line.

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The last item we changed was the ET content. We have not talked about blend at all in the other cigarettes, but it is difficult to talk about ultra-low tar cigarette design without including ET. Due to the ability to take a half per cent weight reduction for each per cent ET substituted, its use has become very widespread to reduce all deliveries. Accordingly, our ultra-light model has doubled its ET content, so it is now 20%. Aside from effecting deliveries, the extra ET will do several other things. RTD per unit length of the tobacco column is increased by ET. This explains the higher rod RTD portrayed. The ET will also burn faster, causing a decrease in puff count.

We are now ready to check our numbers. Our tow item will reduce the 28.6 mg available tar to 10.0 mg. Checking the Tar Reduction vs. % Dilution Chart, we find tar will be reduced 57% at 55% ventilation. This will reduce the tar to 4.3 mg, too low for our 5 mg target. Before altering the ventilation level, we should check the total cigarette RTD to see where we stand. The RTD Reduction vs. % Ventilation shows a 33% reduction in RTD. This will put us at 4.4 inches, which is also below our target. It seems evident by now we will have to decrease the ventilation to increase our RTD and tar delivery. If we move it back to 50%, the RTD reduction becomes 30%. This gives us our 4.6 inch target RTD exactly. Turning to tar reduction, 50% dilution will decrease tar by an equal amount, 50%. This cuts our remaining 10 mg tar in half, just where we want it.

The CO Reduction vs. % Dilution graph shows 50% dilution will decrease CO 60%. That will decrease the 13 mg CO all the way to 5.2 mg, in line with expected values.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

DESIGN PHILOSOPHY
GUIDELINES

1. MAXIMIZE TAR PER PUFF.

2. MINIMIZE PUFF COUNT TO ACHIEVE ITEM 1.

3. MAINTAIN TOTAL RTD BETWEEN 4 AND 5 INCHES. (102-127MM)

4. CHOOSE MID-RANGE CIGARETTE PAPER TO ALLOW FOR DELIVERY FINE TUNING.

5. DO NOT GO BELOW 1.6 DPF TOW.

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DESIGN PHILOSOPHY

BASIC RULES

1. FOR EXISTING BRANDS, DON'T CHANGE PUFF COUNT MORE THAN 1 PUFF AT A TIME.

2. CHANGES IN TAR PER PUFF LESS THAN ± 10% ARE NOT SUBJECTIVELY DETECTABLE.

3. FILTER LENGTH CHANGES - SMALL INCREMENTAL CHANGES ONLY - CAN'T CHEAT THE CUSTOMER - SAME FOR CIGARETTE LENGTH.

4. TRY TO MINIMIZE TOTAL RTD CHANGES.

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GENERAL CIGARETTE DESIGN STEPS

1. Choose FTC tar target (nicotine, CO, etc.).
2. Choose cigarette length.
3. Choose filter length.
4. Choose total RTD target.
5. Choose mid-range cigarette paper.
6. Determine total available FTC tar.
7. Choose an approximate filter efficiency (dilution mix)
8. Choose a filter tow item whose efficiency, in combination with the dilution level, will allow you to reach your tar delivery target at the chosen total RTD.
9. Maximize tar per puff through puff count, ~~ET, AL,~~ ETC
10. Make sample cigarettes - test.
11. Refine cigarette through changes in cigarette paper, tipping paper length, dilution level, etc. to achieve delivery targets at acceptable machine efficiency levels.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure I.-4

HYPOTHETICAL CIGARETTE DELIVERY REDUCTIONS

FULL FLAVORED BRANDS

Unventilated to Ventilated

	THUMPER K.S. (Unventilated)	THUMPER K.S. (Ventilated)
FTC Tar (mg/cigt)	17	** 16
Nicotine (mg/cigt)	1.20	1.20
Puff Count	9	9
% Dilution ($\pm$ 5%)	0	* 10
CO (mg/cigt)	18	** 16
Tobacco Column Length (mm)	63	63
Filter Length (mm)	21	21
Tipping Paper (mm)	25	25
Butt Length (mm)	28	28
Tobacco Column Smoked (mm)	56	56
Available Tar (mg/TCS)	32	32
Total RTD (in/mm)	4.7/119	* 4.5/114
Rod RTD (in/mm)	1.8/46	1.8/46
Filter Plug RTD (in/mm)	2.9/74	2.9/74
Tow Item	3.3/44,000	3.3/44,000
Filtration Efficiency (%)	47	* 45
ET Content (%)	10	10
Cigarette Paper Type	16 SEC/.8%C	* 12/SEC/.8%C

* Construction Changes

** Analytical Changes

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure I.-5

HYPOTHETICAL CIGARETTE DELIVERY REDUCTIONS

FULL FLAVORED TO LOW TAR BRANDS VENTILATED

	THUMPER K.S. (Ventilated)	THUMPER K.S. LIGHTS (Ventilated)
FTC Tar (mg/cigt)	16	** 11
Nicotine (mg/cigt)	1.20	** .85
Puff Count	9	** 8
% Dilution ($\pm$ 5%)	10	* 20
CO (mg/cigt)	16	** 13
Tobacco Column Length (mm)	63	* 57
Filter Length (mm)	21	* 27
Tipping Paper (mm)	25	* 31
Butt Length (mm)	28	* 34
Tobacco Column Smoked (mm)	56	* 50
Available Tar (mg/TCS)	32	* 28.6
Total RTD (in/mm)	4.5/114	* 5.0/127
Rod RTD (in/mm)	1.8/46	* 1.6/41
Filter Plug RTD (in/mm)	2.9/74	* 4.0/102
Tow Item	3.3/44,000	* 3.7/48,000
Filtration Efficiency (%)	45	* 55
ET Content (%)	10	10
Cigarette Paper Type	12 SEC/.8%C	* 16 SEC/.8%C

* Construction Changes

** Analytical Changes

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Figure I.-6

HYPOTHETICAL CIGARETTE DELIVERY REDUCTIONS

LOW TAR TO ULTRA LOW TAR BRANDS
VENTILATED

	THUMPER K.S. LIGHTS (Ventilated)	THUMPER K.S. ULTRA LIGHTS (Ventilated)
FTC TAR (mg/cigt)	11	** 5
Nicotine (mg/cigt)	.85	** .40
Puff Count	8	** 7
% Dilution (± 5%)	20	* 50
CO (mg/cigt)	13	** 5
Tobacco Column Length (mm)	57	57
Filter Length (mm)	27	27
Tipping Paper (mm)	31	31
Butt Length (mm)	34	34
Tobacco Column Smoked (mm)	50	50
Available Tar (mg/TCS) per gm Tobacco Column	28.6	28.6
Total RTD (in/mm)	5.0/127	* 4.6/117
Rod RTD (in/mm)	1.6/41	* 2.0/51
Filter Plug RTD (in/mm)	4.0/102	* 4.6/117
Tow Item	3.7/48,000	* 3.0/48,000
Filtration Efficiency (%)	55	* 65
ET Content (%)	10	20
Cigarette Paper Type	16 SEC/.8%C	* 12 SEC/1.0% C

* Construction Changes

** Analytical Changes

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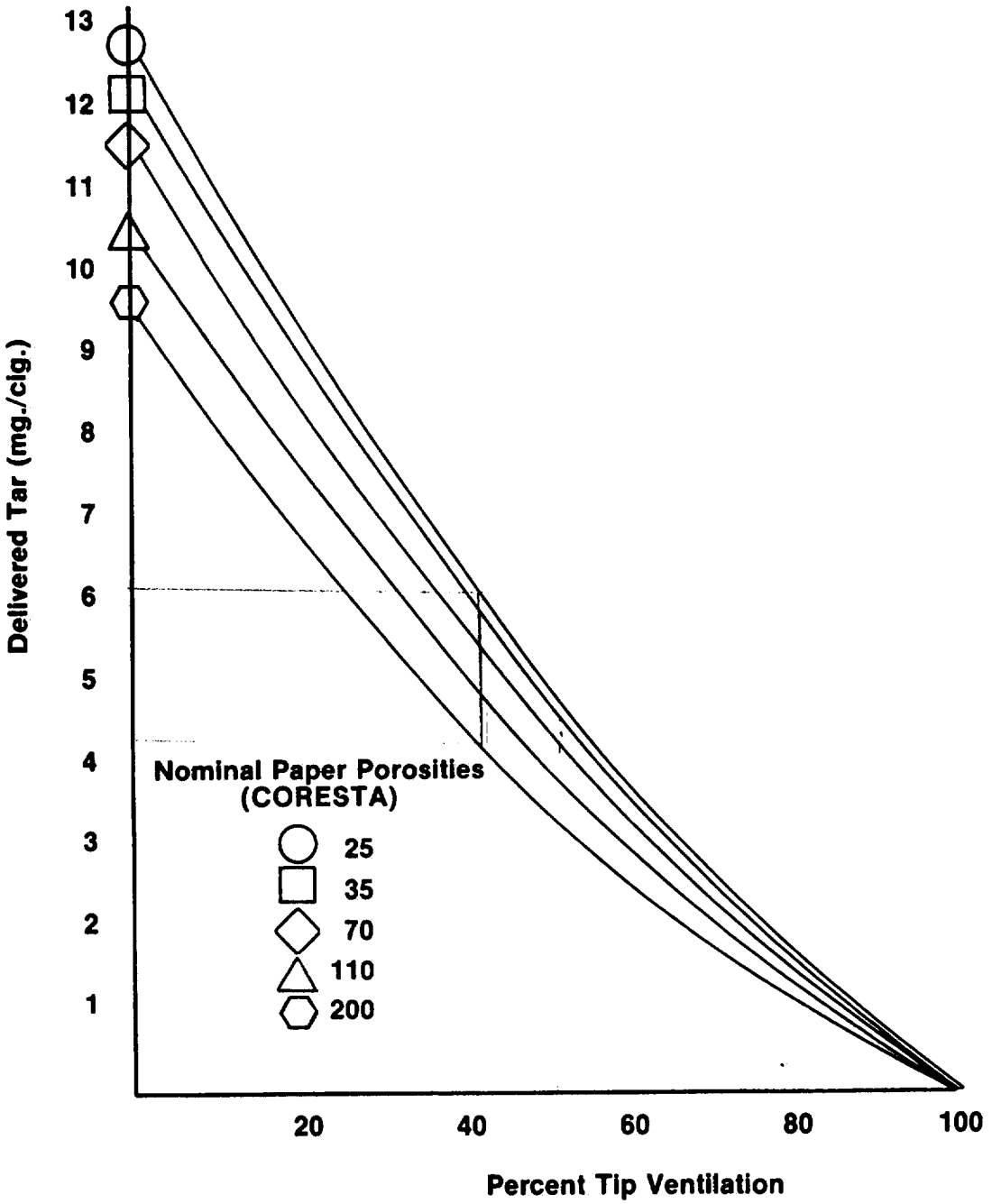
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF CIGARETTE PAPER POROSITY ON VENTILATED TIP TAR DELIVERY



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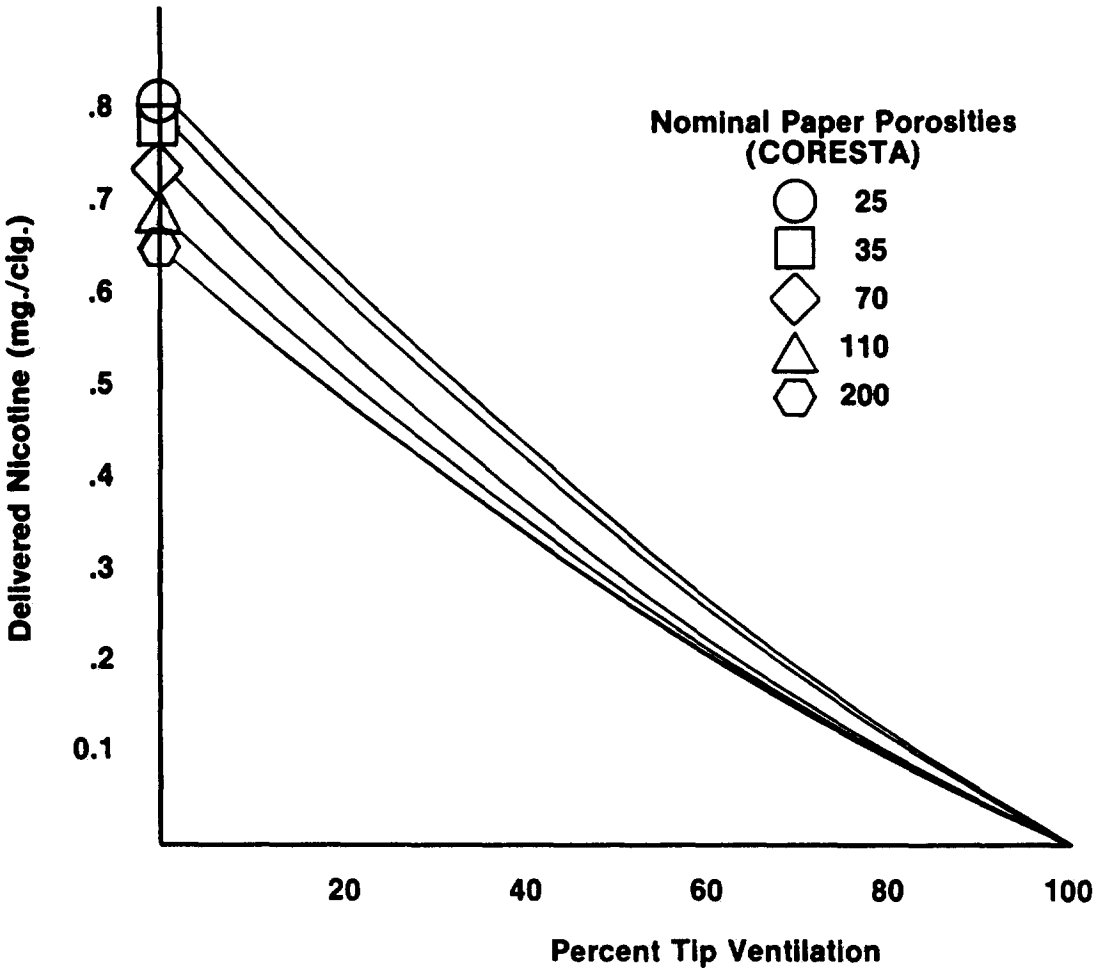
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

EFFECT OF CIGARETTE PAPER POROSITY ON VENTILATED TIP NICOTINE DELIVERY



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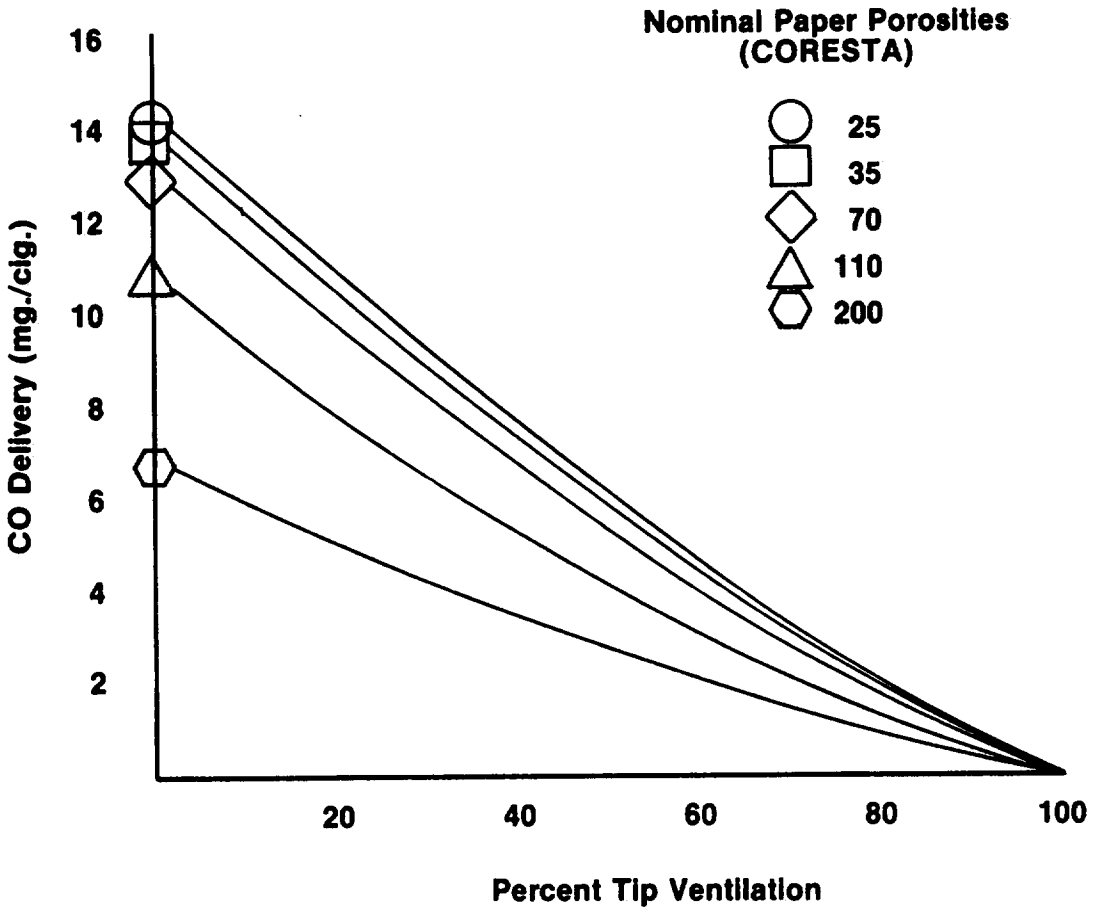
EFFECT OF CIGARETTE PAPER POROSITY ON VENTILATED TIP CO DELIVERY



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PATENTS

CANADA

Can. 913486: Filter cigarette--with an arrangement for diluting smoke with air. Assigned to J. Plourde (1972).

FRANCE

Fr. 1,425,729: Improvements to cigarettes (perforated filter connecting band). Assigned to Imperial Tobacco Ltd. (1965).

Fr. 2,032,311: Heat sensitive laminated ventilation flaps--in a cigarette paper or pipe bowl to assist. Assigned to KH Steigerwald (1970).

Fr. 2,206,663: Ventilated filter-tip for cigarettes--for reducing harmful products by dilution of smoke. Assigned to Bardou-JOB & Pauilhac (1974).

Fr. 2,408,315: Cigarette filter designed to dilute inhaled smoke--has weakening lines split open by pressure of smoker's thumb and index finger. Assigned to V. Flax (1979).

GREAT BRITAIN

Brit. 1,039,554: Cigarettes (with perforated covering). Assigned to Imperial Tobacco Ltd. (1966).

Brit. 1,198,772: Cigarette mouthpiece ventilator. Assigned to Philip Morris Inc. (1970).

Brit. 1,232,456: Cigarette paper (ventilated). Assigned to Bardou-JOB & Pauilhac (1967).

Brit. 1,308,661: Air diluter element for cigarettes--grooved fibre rod allows radial air entry. Assigned to Cigarette Components Ltd. (1973).

Brit. 1,420,908: Ventilated cigarette filter tip--with ventilation index of paper wrap controlled by impervious coating of selected area. Assigned to British-American Tobacco Ltd. (1976).

Brit. 1,505,256: Mouthpiece for cigars, etc.--with ventilation groove to mix air with the smoke and reduce carbon monoxide content. Assigned to British-American Tobacco Ltd. (1976).

Brit. 1,533,568: Cigarette filter containing activated carbon--with ventilating holes in paper band. Assigned to British-American Tobacco Ltd. (1977).

Brit. 2,001,841: Ventilated filter cigarettes--made by joining filter with perforated wrapper to tobacco rod using perforated uniting band. Assigned to Molins Ltd. (1979).

Brit. 2,015,318: Ventilated cigarette filters using perforated cork web--having transverse stripes of adhesive between longitudinally extending main area of adhesive. Assigned to Molins Machine Co. (1979).

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Brit. 2,065,091: Filter for removing nitric oxide, especially from tobacco smoke--comprises activated carbon containing absorbed C-nitroso compounds, especially aromatic compounds. Assigned to British-American Tobacco Ltd. (1981).

Brit. 2,065,444: Compacting tow to form cigarette filter--in tube where tow filaments are folded transversely across filter rod. Assigned to Filtrona Ltd. (1981).

Brit. 2,066,130: Ventilated cigarette manufacturing apparatus--adjusts position of resultant perforations relative to mouth end of cigarette to select required ventilation degree. Assigned to Molins Ltd. (1981). [Apparatus patents have not been generally included in this search unless they reference a particular means of ventilation/dilution.]

JAPAN

Jap. 56-15683: Tobacco filter has hole(s) for the introduction of air--into the smoke upstream of a catalyst for the oxidation and removal of carbon monoxide. Assigned to Matsushita Electric Industries KK (1981).

SOUTH AFRICA

S.Afr. 74-07647: Ventilated filter-tipped cigarette--has uniform porosity strip and envelope enclosing filter. Assigned to British-American Tobacco Ltd. (1975).

S.Afr. 78-01450: Cigarette filter with peripheral vent chamber--allowing mixing of majority of smoke with ventilating air. Assigned to J. Tilburg (1980).

SOVIET UNION

USSR 626679: Cigarette with ventilation channels--between wrapping and strip with removable blocks at different distances from end. Assigned to Philip Morris Inc. (1979).

UNITED STATES

U.S. 3,220,418: Ventilated cigarette. No assignee noted (1965).

U.S. 3,240,213: Cigarette (with ventilated tip). No assignee noted (1966).

U.S. 3,283,762: Aeratable cigarette. No assignee noted (1966).

U.S. 3,394,708: Cigarette with air dilution means. No assignee noted (1968).

U.S. 3,410,274: Cigarettes. Assigned to Imperial Tobacco Company (of Great Britain & Ireland) Ltd. (1968).

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U.S. 3,410,275: Cigarette filter. No assignee noted (1968).

U.S. 3,441,028: Apparatus for and method of removing condensible compounds from smoke. No assignee noted (1969).

U.S. 3,482,579: Filter cigarette having a permeable band wrap. Assigned to Imperial Tobacco Company (of Great Britain & Ireland) Ltd. (1969).

U.S. 3,490,461: Cigarette ventilation. Assigned to Philip Morris Inc. (1970).

U.S. 3,511,247: Smoking product and method of making the same. Assigned to Philip Morris Inc. (1970).

U.S. 3,512,537: Adjustable aerated cigarette. Assigned to U.S. Remedy Corp. (1970).

U.S. 3,606,892: Delayed ventilation cigarette. Assigned to Philip Morris Inc. (1971).

U.S. 3,631,864: Cigarette filter. Assigned to R. J. Reynolds Tobacco Co. (1972).

U.S. 3,631,867: Smoke filter. Assigned to R. J. Reynolds Tobacco Co. (1972).

U.S. 3,701,353: Cigarette perforating apparatus. Assigned to Philip Morris Inc. (1972).

U.S. 3,705,588: Degraded resin coating--for ventilated cigarette wrapper allowing dilution of drawn smoke. Assigned to Philip Morris Inc. (1972).

U.S. 3,707,975: Filter cigarette having apertured band. Assigned to Imperial Tobacco Ltd. (1973).

U.S. 3,739,785: Cigarette with coated wrapper ventilation flaps. Assigned to Philip Morris Inc. (1973).

U.S. 3,742,963: Cigarette perforating device. No assignee noted (1973).

U.S. 3,805,799: Cigarette ventilation achieved with coated wrapper. Assigned to Philip Morris Inc. (1974).

U.S. 3,805,800: Ventilated filter tip cigarette. Assigned to Brown & Williamson Tobacco Corp. (1974).

U.S. 3,924,643: Ventilated filter tip cigarette. Assigned to Brown & Williamson Tobacco Corp. (1974).

U.S. 3,957,064: Smoke diluter to facilitate giving up smoking--has aperture tubular diluting body with ribs guiding it in metal sleeve. Assigned to D.J.M.C. Mestre (1976).

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U.S. 4,023,576: Cigarette mouthpiece for controlling flow--has chamber with baffles at inlet, orifice and grooves in body to draw in dilution air. Assigned to Liggett & Myers, Inc. (1977).

U.S. 4,094,324: Perforated cigarette tipping paper. No assignee noted (1978).

U.S. 4,127,025: Ventilated cigarette with tobacco and filter end--has perforated filter envelope to provide leakage path into wrapping near filter end diluting inhaled smoke. Assigned to Molins Ltd. (1977).

U.S. 4,219,030: Filter construction for cigarette--includes peripheral annular groove to allow ingress of air to filter body to dilute smoke. Assigned to Liggett Group Inc. (1979).

U.S. 4,237,908: Filter-tip cigarette manufacturing process--divides paper by rotary knife to form gap proportional to desired smoke dilution. Assigned to SEITA (1979).

U.S. 4,256,122: Ventilating filter for cigarette--is porous cylinder with straight or helical grooves along longitudinal periphery covered with impermeable envelope. Assigned to Brown & Williamson Corp. (1980).

U.S. 4,273,141: Smoke filter for cigarette--includes filter body with cavity and holes in wrapper for admission of extra air. Assigned to J. Van Tilburg (1980).

U.S. 4,294,265: Filter cigarette with inlet vent zones--has inlet vents in filter mouthpiece in two groups with distance between determining dilution draw-resistance. Assigned to Philip Morris Inc. (1981).

U.S. 4,295,478: Tipping paper for air ventilated cigarette--with adhesive coating having void perforated areas. Assigned to RJR Archer Inc. (1981).

WEST GERMANY

Offen. 1,226,017: Cigarette (ventilated). No assignee noted (1966).

Offen. 1,226,473: Cigarette (ventilated). Assigned to Imperial Tobacco Ltd. (1966).

Offen. 1,271,611: Cigarette (with ventilated mouthpiece). No assignee noted (1968).

Offen. 2,943,561: Filter-tip cigarette--has connecting strip of highly porous paper with barrier layer keeping ventilation zone free. Assigned to Sihlpack AG (1981).

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CANADA

AN - 72587T/46 (72)
I - Filter cigarette - with an arrangement for diluting smoke with air
DC - D18
PA - (PLO /) PLOURDE J
PN - CA-913486-T46

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IPERIAL TOBACCO CO., LTD.
Improvements to cigarettes (perforated filter connecting band). Fr. Pat. Spec. No. 1,425,729, 1965.
Tob. Bibliog. 13(6):No. 642, Mar. 25, 1966. TA 10: 2528

AN - 50276R/28 (70)
TI - Heat sensitive laminated ventilation flaps - in a cigarette paper or pipe bowl to assist
DC - A11 A97
PA - (STE /) STEIGERWALD KH
PN - BE-744413-R28 NL7000505-R29 FR2032311-S06 DE1962217-S24 CH-505570-S24 SU-332600-T49

AN - 65053V/37 (74)
TI - Ventilated filter-tip for cigarettes - for reducing harmful prods by dilution of smoke
DC - D18 P15
PA - (BARD-) BARDOU-JOB & PAUILHAC; (JOBB) SOC JOB ANC ETAB BARDOU
PN - FR2206663-V37 CH-585526-Y18

AN - E7367B/21 (79)
TI - Cigarette filter designed to dilute inhaled smoke - has weakening line split open by pressure of smoker's thumb and index finger
DC - P15
PA - (FLAX/) FLAX V
PN - WP7900269-B21 FR2408315-B34 EP---7375-C06

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GREAT BRITAIN

VIS, A. C.
Cigarettes [with perforated covering]. Brit. Pat. Spec. No. 1,039,554, 1966 to Imperial Tobacco Co. Ltd.
Tob. Bibliog. 16(5):No. 584, Sept. 10, 1967. TA II: 2875

AN - 50040R/28 (70)
TI - Cigarette mouthpiece ventilator
DC - A11 A97 P15
PA - (PHIM) PHILIP MORRIS INC
PN - GB1198772-R28 CA-847633-R31 DE1657261-T06 NL-152748-Y20

SOC. JOB ANCIENS ETAB. BARDOU JOB ET PAUILHAC.
Cigarette paper [ventilated]. Brit. Pat. Spec. No. 1,232,456, 1967.
Tob. Bibliog. 15(9):No. 905, May 10, 1967. TA II: 2112

AN - 11826U/09 (73)
TI - Air diluter element for cigarettes - grooved fibre rod allows radial air entry
DC - D18 P15
PA - (CIGA) CIGARETTE COMPONENTS LTD
PN - GB1308661-U09 DS2107850-X26

AN - 04267X/03 (76)
TI - Ventilated cigarette filter tip - with ventilation index of paper wrap controlled by impervious coating of selected area
DC - D18 P15
PA - (BRTA) BRIT AMER TOBACCO LTD
PN - GB1420908-X03

AN - B0250X/05 (76)
TI - Mouthpiece for cigars etc. - with ventilation groove to mix air with the smoke and reduce carbon monoxide content
DC - P15
PA - (BRTA) BRIT AMER TOBACCO LTD
PN - NL7509060-X05 DE2529315-X06 BR7504389-X30 CH-588827-Y29 GB1505256-A13 CA1029265-A17

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AN - 29159Y/17 (77)
TI - Cigarette filter conts. activated carbon - with ventilating holes in paper band
DC - D18 P15
PA - (BRTA) BRIT AMER TOBACCO LTD; (SOUZ-) CIA SOUZA CRUZ IND
PN - BE-849482-Y17 NL7613432-Y27 DE2654698-Y27 DK7605686-Y36 FI7603453-Y38 ZA7606954-Y46 BR7608510-A03 CH-604577-A41 GB1533568-A48 CA1045496-B04

AN - B4130B/07 (79)
TI - Ventilated filter cigarettes - made by joining filter with perforated wrapper to tobacco rod using perforated uniting band
DC - P15
PA - (MOLM) MOLINS LTD
PN - GB2001841-B07 DE2832988-B09 SE7808377-B12 FR2399220-B19 BR7805028-B20 CA1092931-D07

AN - H8137B/37 (79)
TI - Ventilated cigarette filters using perforated cork web - having transverse stripes of adhesive between longitudinally extending main area of adhesive
DC - P15
PA - (MOLM) MOLINS MACHINE CO
PN - GB2015318-B37

AN - 21478D/13 (81)
TI - Filter for removing nitric oxide, esp. from tobacco smoke - comprises activated carbon conts. absorbed C-nitroso cpd. esp. aromatic cpd.
DC - D18 E14 J01 P15
PA - (BRTA) BRIT AMER TOBACCO LTD
PN - BE-886144-D13 NL8006172-D25 BR8007475-D25 DE3041383-D25 GB2065091-D26 NO8003389-D27 SE8007879-D28 FR2469134-D29 FI8003409-D30 JS6084631-D35 DK8004815-D38 ZA8006693-D43

AN - 48229D/27 (81)
TI - Compacting tow to form cigarette filter - in tube where tow filaments are folded transversely across filter rod
DC - A88 D18 F04 A32 P15
PA - (FILT-) FILTRONA LTD
PN - GB2065444-D27

AN - G4272D/28 (81)
TI - Ventilated cigarette mfg. apprts. - adjusts position of resultant perforations relative to mouth end of cigarette to select required ventilation degree
DC - X25 P15 P55 P62
PA - (MOLM) MOLINS LTD
PN - GB2066130-D28 DE3044931-D37

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AN - 24578D/14 (81)
TI - Tobacco filter has hole(s) for the introduction of air - into the smoke upstream of a catalyst for the oxidn. and removal of carbon monoxide
DC - A97 D18 P15
PA - (MATU) MATSUSHITA ELEC IND KK
PN - J56015683-D14

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

AN - G1277W/24 (75)
TI - Ventilated filter-tipped cigarette - has uniform porosity strip and envelope enclosing filter
DC - P15
PA - (BRTA) BRIT AMER TOBACCO LTD
PN - BE-822708-W24 ZA7407647-X06 DE2456614-X25 SE7415081-X29 FI7403483-X35 CH-587617-Y27

AN - C9828C/13 (80)
TI - Cigarette filter with peripheral vent chamber - allowing mixing of majority of smoke with ventilating air
DC - P15
PA - (VTIL/) TILBURG J
PN - ZA7801450-C13

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

AN - G2908B/29 (79)
TI - Cigarette with ventilation channels - between wrappings and strip with removable blocks at different distances from end
DC - P15
PA - (PHIM) PHILIP MORRIS INC
PN - SU-626679-B29

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UNITED STATES

COHN, S. L.; COHN, C. C.
[Ventilated] Cigarette. U. S. Pat. Spec. No. 3,220,418, 1965.
Tob. Bibliog. 13(3):No. 298, Feb. 10, 1966. TA 10: 2509

MILLER, A. P.
Cigarette (with ventilated tip). U. S. Pat. Spec. No. 3,240,213, 1966.
Tob. Bibliog. 13(9):No. 964, May 10, 1966. TA 10: 2908

KISSEL, M. S.
Aeratable cigarette. U. S. Pat. Spec. No. 3,283,762, 1966. TA 11: 410

GRASSI, E.
Cigarette with air dilution means. U. S. Pat. Spec. No. 3,394,708, 1968. TA 12: 2255

DAVIS, A. C.
Cigarettes. U. S. Pat. Spec. No. 3,410,274 to Imperial Tobacco Company (of Great Britain and Ireland) Limited. Offic. Gaz. U. S. Pat. Office 856(2):455, Nov. 12, 1968.
A cigarette having highly permeable areas formed in an otherwise impermeable band covering the joint between the tobacco portion and the stub portion of the cigarette so that as smoke is drawn through the stub air enters the joint through the highly permeable portions. The extent to which the permeable areas cover the joint and the degree of permeability of the areas determines the amount of air drawn in through the joint. (Abstract) TA 13: 566

TUCKER, I. W.
Cigarette filter. U. S. Pat. Spec. No. 3,410,275. Offic. Gaz. U. S. Pat. Office 856(2):455, Nov. 12, 1968.
A cigarette filter having an exposed wrapper portion formed of inherently porous sheet material to permit air to be drawn into the filter material through said inherently porous material upon inhalation of the associated cigarette. (Abstract) TA 13: 623

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WALL, B. T.

Apparatus for and method of removing condensible compounds from tobacco smoke. U. S. Pat. Spec. No. 3,441,028. Off. Gaz. U. S. Pat. Off. 861(5):1452, Apr. 29, 1969. illus.

A smoking utensil such as a cigarette, a cigarette holder or a pipe stem having a smoke passage is provided with an insert in the passage having a smoke channel of smaller cross-section than the smoke passage and temperature responsive means, such as a bimetallic spring, for introducing air into the smoke as it passes through the smoke channel. A filter or other means for holding compounds which are condensed as a result of the cooling effect of the air is positioned in the smoke passage downstream from the insert to hold the tars and the like and thus remove them from the smoke leaving the utensil. (Abstract) TA 13: 1721

DAVIS, A. C.

Filter cigarette having a permeable band wrap. U. S. Pat. Spec. No. 3,482,579 to Imperial Tobacco Company (of Great Britain and Ireland) Limited. Off. Gaz. U. S. Pat. Off. 869(1):455, Dec. 2, 1969. illus.

A cigarette having highly permeable thinned areas formed in the surface of an otherwise substantially impermeable band which band covers the joint between the tobacco portion and the stub portion. The thinned areas overlie the said joint so that as smoke is drawn through the stub, air enters the joint through the highly permeable portions. (Abstract) TA 14: 1879

OSMALOV, J. S.; PASQUINE, A. R.; SELIGMAN, R. B.; BRITTON, A. C.

Cigarette ventilation. U. S. Pat. Spec. No. 3,490,461 to Philip Morris Incorporated. Off. Gaz. U. S. Pat. Off. 870(3):830, Jan. 20, 1970. illus.

A cigarette in which the smoke drawn from the tobacco section is delivered to the smoker's mouth through a central passage in a mouthpiece arranged in alignment with the tobacco section and in fluid communication therewith, the mouthpiece being provided with one or more ventilation passages through which ventilating streams of air are drawn during smoking, the ventilation passages being segregated from the central passage in a manner which prevents commingling of the smoke stream and ventilating streams prior to the delivery of each to the smoker's mouth. (Abstract) TA 14: 840

TAMOL, R. A.

Smoking product and method of making the same. U. S. Pat. Spec. No. 3,511,247 to Philip Morris Incorporated. Off. Gaz. U. S. Pat. Off. 874(2):466, May 12, 1970. illus.

This disclosure relates to a smoking product and method of making the same. More particularly the disclosure relates to a cigarette or similar smoking article which contains covered ventilation holes adapted to open during the smoking of the product to provide smoke diluted by air during the smoking of the product and which provides means for visibly indicating to the smoker the opening of the ventilation holes. (From abstract) TA 14: 1639

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PELLETIER, L. G.

Adjustable aerated cigarette. U. S. Pat. Spec. No. 3,512,537 to U. S. Remedy Corporation. Off. Gaz. U. S. Pat. Off. 874(3):789, May 19, 1970. illus.

An adjustable, aerated cigarette structure in which the cigarette wrapper is provided with a tobacco-free extension surrounding a sleeve, the extension having a circumferential region of pores which register with a ring of slots formed in the sleeve adjacent the end of the tobacco column. A tube is telescopically received in the sleeve, the tube having an opening therein which is so shaped that when the tube is pushed inwardly, it more or less registers with the slots to provide a lateral air passage of varying dimensions. (Abstract) TA 14: 1888

WILSON, G. M.

Delayed ventilation cigarette. U. S. Pat. Spec. No. 3,606,892 to Philip Morris Incorporated. Off. Gaz. U. S. Pat. Off. 890(4):1057, Sept. 21, 1971. illus.

A delayed dilution or ventilation type cigarette in which the cigarette has an inner sleeve of a suitable material enclosing the tobacco filler along a length thereof from the butt end a distance in the direction of the other end. The inner sleeve in turn is enclosed by the conventional or outer paper wrapper of the tobacco cylinder, such sleeve including projections or openings in the surface thereof which cooperate with the inside surface of the outer wrapper to form a series of cigarette ventilation passages within the cigarette structure, the ventilation passages being placed in communication with atmosphere only after about half the length of the tobacco cylinder length has been smoked. (Abstract) TA 16: 880

BEARD, H. S.

Cigarette filter. U. S. Pat. Spec. No. 3,631,864 to R. J. Reynolds Tobacco Company. Off. Gaz. U. S. Pat. Off. 894(1):154, Jan. 4, 1972. illus.

A cigarette filter is provided which comprises a pair of complemental sections formed of smoke-impervious material and arranged in registered relation and affixed to one end of a tobacco rod. Each complemental section is provided with an elongated indentation closed at one end. Sandwiched between the indentations of the complemental sections and cooperating therewith to form a pair of elongated smoke passageways is a thin perforated membrane. A predetermined number of the membrane perforations effect communication between the passageways whereby smoke flowing from one passageway to the other attains a high velocity while passing through a membrane perforation and the high-velocity smoke impinges against a surface of the passageway and causes solid and liquid particles entrained in the emitted smoke to be deposited on said surface. (Abstract) TA 16: 852

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BEARD, H. S.

Smoke filter. U. S. Pat. Spec. No. 3,631,867 to R. J. Reynolds Tobacco Company. Off. Gaz. U. S. Pat. Off. 894(1):155, Jan. 4, 1972. illus.

A smoke filter is provided wherein the filter includes a laminated module provided with a pair of elongated smoke passageways separated from one another by a perforated lamina. The module is encapsulated by an elongated smoke impervious member whereby the upstream end of one module passageway and the downstream end of the other passageway are exposed. The elongated member is initially a solid extruded rod which is subsequently provided with an elongated longitundinally extending slot formed in one side thereof into which the laminated module is inserted. Subsequent to the insertion of the module into the member slot, the open side of the slot is closed thereby encapsulating the module therein. (Abstract) TA 16: 853

PASQUINE, A. R.; SNOW, H. J.; WAGNER, E. E.

Cigarette perforating apparatus. U. S. Pat. Spec. No. 3,701,353. U. S. Pat. Off. Off. Gaz. 903(5): 1564, Oct. 31, 1972. Illus.

A mechanism for perforating cigarettes in conjunction with the operation of assembling filter sections to the cigarettes including the application of a tipping wrap connecting the filter section to the tobacco rod section the mechanism embodying a stationary shoe peripherally adjacent a cigarette carrier drum whereby the tipping paper is wrapped around the sections by rolling the rod sections between the drum and shoe, the shoe having in its surface needle points which penetrate the rod assembly as it is rolled, the needle points being provided by a thin strip of sheet metal appropriately ground at an edge facing the rod sections to provide an arc-shaped row of needles adapted to result in a peripheral row of venting apertures in the assembled cigarette. TA 17: 237

AN - 81058T/51 (72)
TI - Degraded resin coating - for ventilated cigarette wrapper allowing dilution of drawn smoke
DC - A97 D18 A18 A25 P15
PA - (PHIM) PHILIP MORRIS INC
PN - US3705588-T51 BE-785827-U06 SU-458989-X18

DAVIS, A. C.

Filter cigarette having apertured band. U. S. Pat. Spec. No. 3,707,975 to Imperial Tobacco Group, Ltd. U. S. Pat. Off. Off. Gaz. 906(1):158, Jan. 2, 1973. illus.

A cigarette is disclosed having a wrapped tobacco portion and a two section stub secured to it by a band of impermeable material. Beneath the impermeable band, a band of highly permeable material is disposed. The impermeable band is provided with at least one opening adjustable located over the butt joint between the two sections of the stub whereby the amount of air passing into the butt may be controlled. TA 17: 224

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

STEPHENS, W. K., Jr.
Cigarette with coated wrapper ventilation flaps. U. S. Pat. Spec. No. 3,739,785 to Philip Morris Incorporated. U. S. Pat. Off. Off. Gaz. 911(3):871, June 19, 1973. illus.

A ventilated cigarette employing one or more flaps defined by slit patterns in the wrapper thereof and which flaps are adapted to move away from the wrapper encircling course when the cigarette is puffed to admit ventilating or diluting air streams to the tobacco cylinder which is made with the slit pattern fashioned to extend generally transverse of the article longitudinal axis to provide flap movement about a hinge line disposed generally parallel to said longitudinal axis. The slit pattern can be made the form of an X, a V or other suitable configuration. The article further has a coating of an air-impervious normally rigid material on either the inner or outer surface of the wrapper in covering and encircling expanse about each slit pattern and associated flap to normally constrain or hold the flap in the encircling wrapper course. When the cigarette has been smoked to an extent that ventilation is advantageous or desirable, the material responsive to the presence of heat from warm smoke and the burning coal or to the ingredients of tobacco smoke becomes softened and constraint on the flap is released to permit the circular tension in the wrapper to cause the flap to move away from the wrapper encircling course and admit ventilation air.

TA17: 1767

CREAMER, A. B.
Cigarette perforating device. U.S. Pat. Spec. No. 3,742,963. U. S. Pat. Off. Off. Gaz. 912(1):119, July 3, 1973.

A device for perforating the paper tube or wrapping of a cigarette wherein the device has a perforating member for forming a hole in the paper tube, the member being provided with at least one recessed portion which cooperates with the hole to present a substantially unobstracted airflow passage into the cigarette for permitting air to mix with smoke flowing therethrough when the device is used to hold the cigarette after perforating the same.

TA17: 1753

STEWART, L. L., Jr.; HARTUNG, H. A.
Cigarette ventilation achieved with coated wrapper. U. S. Pat. Spec. No. 3,805,799, to Philip Morris Incorporated. U. S. Pat. Off. Off. Gaz. 921(4):1442-1443, Apr. 23, 1974. illus.

A cigarette or smoking article is provided with ventilation or smoke dilution character by employing a wrapper which normally is sufficiently air-pervious to admit significant dilution air stream flow therethrough when the cigarette is puffed. The wrapper is coated on either of its inner or outer surface with an air-impervious material which is degradable in the presence of tobacco smoke, and a coating of a second air-impervious material which is non-degradable in the presence of smoke is embodied in the cigarette and extends a predetermined distance from the cigarette smoking end toward the mouth end to prohibit entry of air stream flow through the wrapper until the cigarette has been smoked said predetermined distance following which the degradable coating on the remaining length degrades to admit such air stream flow.

TA18: 1717

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

SUMMERS, T. W.
Ventilated filter tip cigarette. U. S. Pat. Spec. No. 3,805,800, to Brown & Williamson Tobacco Corporation. U. S. Pat. Off. Off. Gaz. 921(4):1443, Apr. 23, 1974. illus.

An improved ventilated filter cigarette utilizes uniformly porous plug wrap and tipping envelope to provide at least one uniformly porous ventilated region having a predetermined area about the filter. The area and porosity of the region or regions are correlated so as to provide a relationship which, when the limits thereof are observed, provides cigarettes with a more constant, reduced delivery of total particulate matter and gas phase constituents than heretofore obtained by ventilated filter tip cigarettes.

TA18:1718

AN - 56101U/38 (73)
JI - Ventilated filter tip cigarette - with filter in uniform porosity wrapper
DC - D13 P15
PA - (BRTA) BRITISH AMERICAN TOBACCO
PN - ZA7207138-U38 GB1349217-V14 US3805800-V18 CA-962908-W10 CH-569432-X02 DS2251903-Y26 NL-160480-B26

SUMMERS, T. W.
Ventilated filter tip cigarette. U. S. Pat. Spec. No. 3,924,643 to Brown & Williamson Tobacco Corporation. U. S. Pat. Off. Off. Gaz. 941(2): 636, Dec. 9, 1975. illus.

A ventilated filter tip cigarette comprising: a tobacco column; a filter enclosed by a porous, air permeable wrapper, characterized by substantially uniform porosity; a porous envelope characterized by substantially uniform porosity enclosing at least a portion of said enclosed filter, said envelope and wrapper being adhered together along at least one preselected region, but not over the entire area of their contiguous surfaces, the remainder of said contiguous surfaces being adhesive free, at least a portion of the remainder being air permeable to permit ambient air flow therethrough.

TA20:734

AN - F0957X/22 (76)
TI - Smoke diluter to facilitate giving up smoking - has aperture tubular diluting body with ribs guiding it in metal sleeve
DC - P15
PA - (MEST/) MESTRE D J M C
PN - US3957064-X22

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

AN - E4008Y/21 (77)
TI - Cigarette mouthpiece for controlling flow - has chamber with baffles at inlet, orifice and grooves in body to draw in dilution air
DC - P15
PA - (LIGG) LIGGETT & MYERS INC
PN - US4023576-Y21

BOLSINGER, O.; SECKELMANN, I.

Perforated cigarette tipping paper. U. S. Pat. No. 4,094,324. U. S. Pat. Off. Off. Gaz. 971(2):542-543, June 13, 1978.

In a cigarette having at one end, an air permeable filter having a defined porosity along the exterior thereof, a cigarette tipping paper receivable on the exterior of the filter to form a filter tip having a porosity approaching that of the filter alone, said tipping paper having a width in excess of the length of the filter and a length which is at least as great as the circumference of the filter, said paper having at least one perforated zone which is arranged in the longitudinal direction of the paper and having a width corresponding to a fraction of the width of the paper, said zone being bordered by first and second unperforated edge strips which receive the tobacco containing portion of the cigarette and lips of the user, respectively, said perforated zone containing a plurality of minute perforations normally invisible to the naked eye and formed by high tension spark erosion, said perforations being irregular in shape, size and location within said zone and present in a sufficient number to provide a porosity to the zone for establishing the porosity of the filter tip inclusive of the tipping paper at that approaching the porosity of the filter alone.

TA 22: 2272

AN - J0033Y/39 (77)
TI - Ventilated cigarette with tobacco and filter end - has perforated filter envelope to provide leakage path into wrapping near filter end diluting inhaled smoke
DC - P15 R16
PA - (MOLM) MOLINS LTD
PN - DE2710918-Y39 FR2344237-A02 US4127025-A49 GB1564313-C15 GB1564314-C15

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AN - J0284C/37 (80)
TI - Filter construction for cigarette - includes peripheral annular groove to allow ingress of air to filter body to dilute smoke
DC - P15
PA - (LIGG-) LIGGETT GROUP INC
PN - US4219030-C37 ZA7905106-C47 BR7906355-D17 DE2940293-D22 FR2465509-D24 GB2066648-D29

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

AN - F5331B/26 (79)
TI - Filter-tip cigarette mfg. process - divides paper by rotary knife to form gap proportional to desired smoke dilution
DC - P15
PA - (SETB) SERVICE EXPL IND TABACS
PN - BE-874305-B26 DE2907150-B37 GB2016256-B39 FR2417950-B49 US4237908-D01 SU-791201-D37

AN - H2055C/34 (80)
TI - Ventilating filter for cigarette - is porous cylinder with straight o helical grooves along longitudinal periphery covered with impermeable envelope
DC - P15
PA - (BRWI) BROWN & WILLIAMSON CORP; (BRTA) BRIT AMER TOBACCO LTD
PN - BE-882617-C34 BR8002325-C39 NL8001948-C44 DE3011959-C44 GB2046573-C47 NO8000959-C48 SE8002712-C48 FI8001127-D01 FR2453610-D06 DK8001540-D08 US4256122-D14 ZA8001947-D37

AN - C8768D/14 (81)
TI - Smoke filter for cigarette - includes filter body with cavity and holes in wrapper for admission of extra air
DC - P15
PA - (VTIL/) VAN TILBURG J
(- CA1096737-D14 US4273141-D27 GB1602962-D47

AN - L4486D/44 (81)
TI - Filter cigarette with inlet vent zones - has inlet vents in filter mouthpiece in two groups with distance between determining dilution and draw-resistance
DC - P15
PA - (PHIM) PHILIP MORRIS INC
PN - US4294265-D44 EP--38148-D44

AN - 79202C/45 (80)
TI - Tipping paper for air ventilated cigarette - with adhesive coating having void perforated areas
DC - A97 D18 G03 A81 P15
PA - (RETO) RJR ARCHER INC
PN - EP--17794-C45 NO8000954-C48 DK8001518-C49 BR8002154-C50 FI8001030-D01 PT--71048-D20 CS8002424-D38 DD-150000-D45 US4295478-D45

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

WEST GERMANY

MAI, L.
Cigarette [ventilated]. Ger. Pat. Spec. No. 1,226,017, 1966.
Tob. Bibliog. 14(12):No. 1290, Dec. 25, 1966. TA II: 865

IMPERIAL TOBACCO CO. LTD.
Cigarette [ventilated]. Ger. Pat. Spec. No. 1,226,473, 1966.
Tob. Bibliog. 15(1):No. 86, Jan. 10, 1967. TA II: 855

MILLER, A. P.
Cigarette [with ventilated mouthpiece]. Ger. Pat. Spec. No. 1,271,611, 1968.
Tob. Bibliogr. 18(5):No. 601, Sept. 10, 1968. TA 13: 267

(- C9312D/14 (81)
T1 - Filter-tip cigarette - has connecting strip of highly porous paper with barrier layer keeping ventilation zone free
DC - P15
PA - (SIHL-) SIHLPACK AG
PN - DE2943561-D14

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

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37. Tobacco International, December 25, 1981, pp. 73 - 78.

38. Tobacco Reporter, June 1982, pp. 30 - 37

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II. Quality Assurance

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QUALITY ASSURANCE

FOR

VENTILATED PRODUCTS

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A. General Principles

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GENERAL

PRINCIPALS

OF

VENTILATION

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II. Quality Assurance for Ventilated Products

A. General Principals of Ventilation

1. What is it?

Ventilation is the introduction of outside air into the filter through perforations in the tipping paper. This air is allowed to mix with and dilute the mainstream cigarette smoke passing through the filter.

2. Why have it?

Through ventilation we can control the tar, nicotine, and carbon monoxide delivery of the cigarette.

Equally as important, we can also control and maintain full flavor of the cigarette.

3. What affects ventilation? (See Attachment A1)

Plugwrap, tipping paper, cigarette paper, filter RTD and tobacco column density (RTD) all have a role in determining final product ventilation. (See Attachment A1)

4. General Relationship between Cigarette Parameters and Ventilation

a. In general ventilation increases as the pressure drop upstream of the vents increases.

b. Tobacco column density - the more dense the column the greater the ventilation.

c. Cigarette Paper - the less porous the paper the greater the ventilation.

d. Tipping Paper - the more porous the tipping the greater the ventilation.

e. Plugwrap - the more porous the plugwrap the greater the ventilation.

f. Filter Plug - an increase in length upstream from the vents increases ventilation.

5. Types of Ventilation/Perforation (See Attachment A2)

a. Electrostatic

1) Process - electric sparks produce a band of small perforations in the tipping paper.

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2) Advantages - perforations are not visible on the finished cigarette. The process is relatively inexpensive.

3) Disadvantages - there are limitations on the degree of dilution attainable. The process is slower than laser.

4) Dilution Range - the percent dilution is limited to approximately 30% on cork tipping and 20% on white.

5) General Comments - porous plugwrap and skip tip adhesive application are required.

b. Mechanical

1) Process - rows of visible holes produced by piercing the tipping paper.

2) Advantage - has higher dilution range than "on machine" mechanical perforation method. Although holes are visible they are evenly spaced.

3) Disadvantage - is being done by outside vendor because of cost. Holes are visible.

4)* Dilution Range - the percent dilution could go as high as 100%.

5) General Comments - porous plug wrap and skip tip adhesive are required.

c. Hauni Pin

1) Process - set of pins put a single row of holes in finshed cigarette as it is being rolled.

2) Advantages - perforating is done on the tipper therefore non-porous plug wrap can be used and no skip gap pattern is needed.

3) Disadvantages - cannot be used on high speed equipment. Machine downtime generated in replacing and adjusting pins.

4)* Dilution Range - the % dilution is limited to approximately 30%.

5) Comments - non-porous plugwrap and tipping can be used. Skip tip adhesive application is not necessary.

* See Attachment A3

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d. Laser

1) Process - the laser "burns" small holes in the tipping paper.

2) Advantages - gives a more uniform hole size and pressure drop. The % dilution is unlimited. Can run at extremely high speeds.

3) Disadvantages - cannot rework improperly perforated tipping. Possibly need people with higher degree of technical training to maintain lasers.

4)* Dilution range - the percent dilution can be as great as 100%.

5) Comments - porous plug wrap and skip tip adhesive application are required.

e. Max S Laser

1) Process - finished cigarette is rolled under a laser perforator on the tipper.

2) Advantages - can be used on high speed equipment. Gives a higher dilution range than mechanical "on machine" method.

3) Disadvantage - cannot attain as high a dilution as with off-line laser or mechanical perforators.

4)* Dilution range - the percent dilution is limited to approximately 50%.

5) Comments - non-porous plug wrap and tipping can be used and no skip tip adhesive pattern is required.

* See Attachment A3

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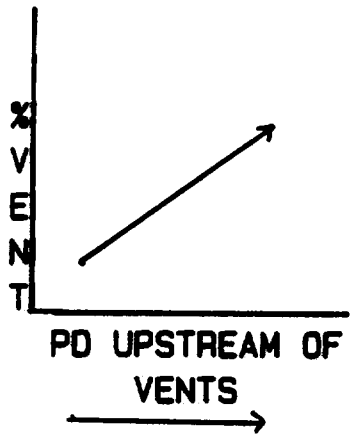
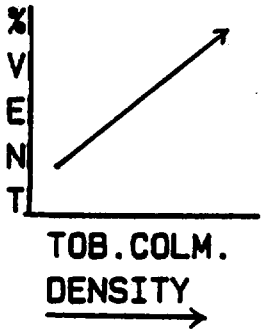
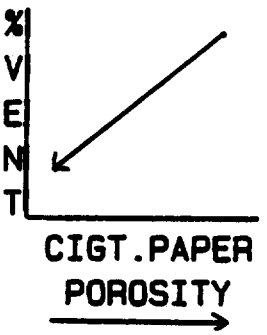
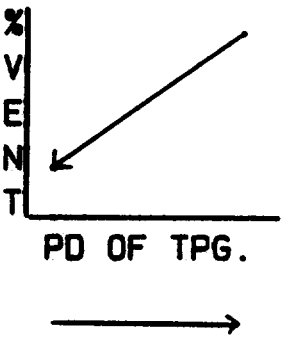
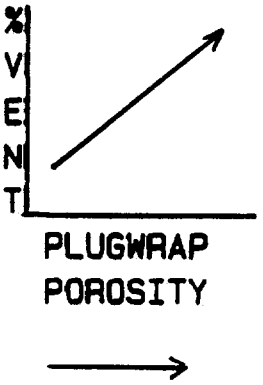
WHAT AFFECTS VENTILATION ?

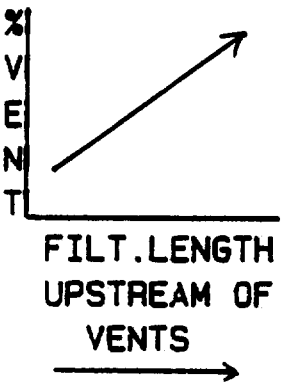


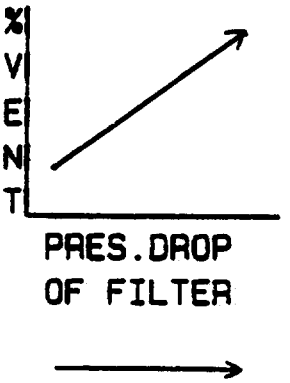












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TYPES OF PERFORATION

TYPES	HOW PERFORATED	% VENT. UPPER LIMIT	POROUS PLUGWRAP REQUIRED	PERF. TIPPING REQUIRED	SKIP TIP REQUIRED
ELECTROS.	ELECTRIC SPARK	30%	YES	YES	YES
MECHANICAL	"PIERCING"	100%	YES	YES	YES
HAUNI PIN	"PIERCING"	30%	NO	NO	NO
LASER	"BURNING"	100%	YES	YES	YES
MAX S LASER	"BURNING"	50%	NO	NO	NO

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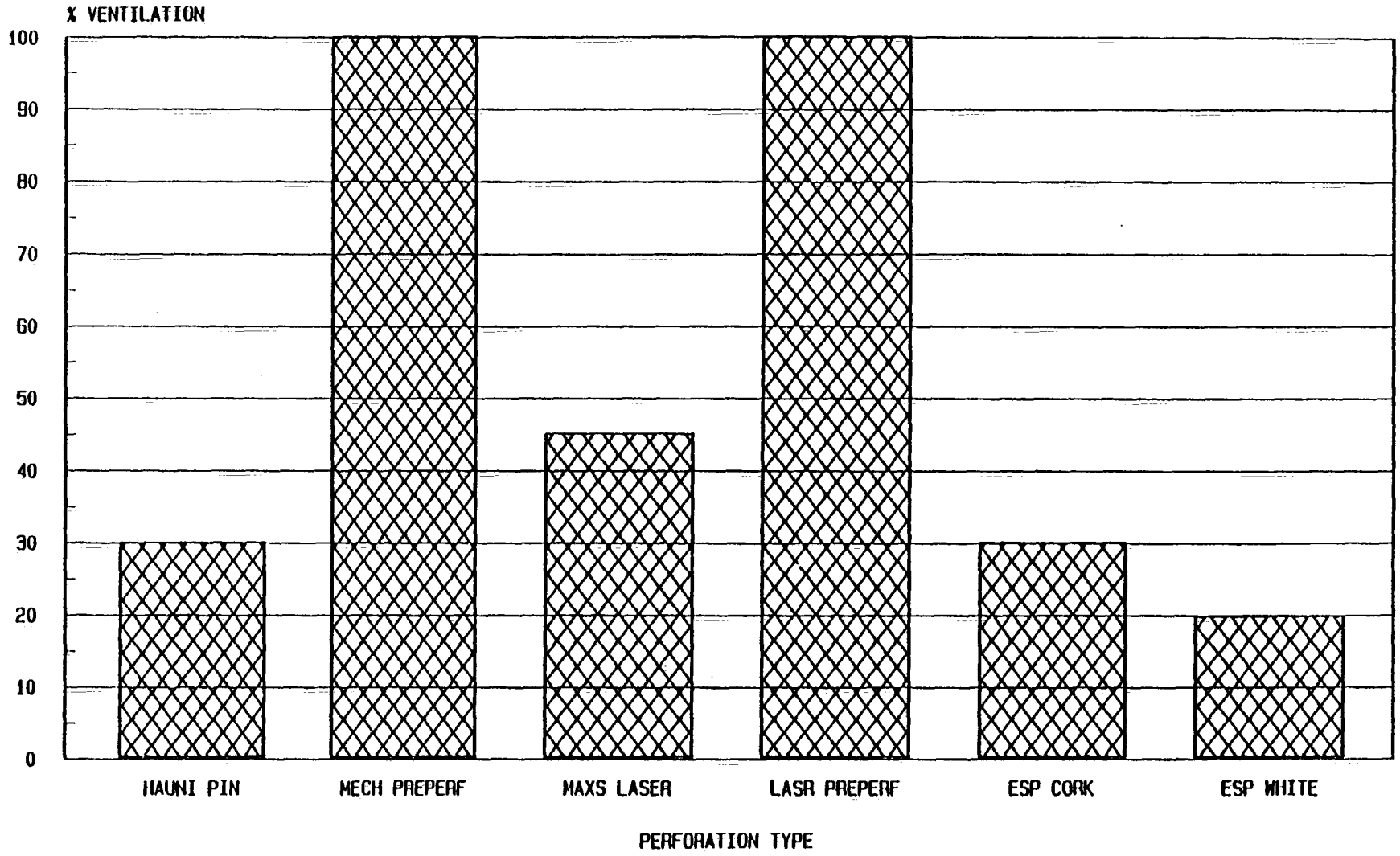
TYPE PERFORATION VS.

VENTILATION LIMITAIONS



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DMCP

Direct Materials Conversion Plant

B. DMCP

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DIRECT

MATERIALS

CONVERSION

PLANT

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B. Direct Materials Conversion Plant

1. General Overview of DMCP Operations

a. Pallets of tipping paper for perforation are kept right at the perforators (ESP)

b. The production floor consists of numerous perforators.

c. As tipping paper is perforated it is inspected by Quality Assurance.

d. Once perforated the bobbins are re-palletized and checked for proper identification and stacking.

e. Pallets are then sent to shipping where they are wrapped in plastic and sent to the warehouse until needed.

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2. Quality Assurance function at DMCP.

a. Objective

To insure that each bobbin is perforated, that perforated brands meet specification standards, and that other defects such as registration, splices, etc. are within desired limits.

b. What Quality Assurance Checks

1) Pressure drop

The pressure drop is directly related to the dilution of a cigarette. The higher the PD the lower the dilution and likewise the lower the PD the higher the diltuion of a cigarette. The term "dilution" refers to the mixture or ratio of smoke drawn through the cigarette mixed with the air drawn through the perforated holes in the tipping paper. This air drawn in through the perforated holes dilutes or thins the smoke content being drawn from the burning tobacco.

2) Band Position

Band position is important because it allows the perforated holes to be far enough away from the mouth to pull in the proper amount of outside air to achieve advertised dilution of tar and nicotine. In the production of cigarettes the machinery is geared so that a glue applicator can spread a thin glue layer on the tipping paper and not close the perforated holes which would drastically change the PD/diltuion of the cigarette.

3) Visual Examination

Visual examination includes checks for color, creases, registration, print, holes, tears, broken edges, ink spots, electro burns, contamination by oil, dirt, bugs, etc.

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c. The responsibilties of a QA DMCP Technician (See Attachment B1)

1) Determine the disposition/quality of perforated materials produced in the Direct Materials Conversion Plant by using a Pressure Drop Instrument, optical comparator with appropriate overlays, specifications provided to the QA Department by Operations Services and continual observation of laser monitors for anomalies when in that area. (See Attachments B2 & B3 for examples of specifications)

2) To communicate effectively with all supervision and production personnel concerning substandard work and of machines that are showing trends to run to either side of the target and any other abnormalities. Production supervision should be notified if the technician places a bobbin on HOLD or a bobbin is produced with bad edges; in both instances the QA Supervisor is notified immediately to determine final disposition of the questionable material.

3) The relief personnel are responsible for making out the correct control charts for the various shifts, and the technician at the station is ultimately responsible for the final corrections and all information appearing on the chart.

4) The QA Technician is directly responsible for the proper use of the instruments at their stations, their calibration when necessary and notifying their supervisor when there is a malfunction they cannot correct, and accurately recording data they acquire.

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d. Quality Assurance Procedures

1) Sampling

a) In the ESP area every fourth bobbin is being sampled and in the laser area every other bobbin is sampled by the QA Technician. The sample consist of a strip from the outside wrap of the bobbin. Each sample strip is inspected fully and any defect causing a rejection is noted and production supervision notifed.

2. Pressure Drop (See Attachment B4)

a) Beginning with the first machine assignment, collect a sample strip from each machine's first bobbin run.

b) Check the first bobbin produced from each machine at start up and every 4th bobbin there after for a complete inspection if in the ESP area and every other bobbin in the laser area unless bad work is detected.

c) Position the test strip in the test clamp with the inside to the top. Be sure the correct spacer clip is in place.*

d) Take 5 readings from the inside perforated band from 5 different areas and 5 readings from the outside perforated band. Average the readings for each side for each band and record the results on the control chart.

e) When a bobbin is found to exceed the control limit specifications, resample the bobbin and obtain a second test strip. Reinspect the pressure drop, etc., on that bobbin.

f) If the bobbin, still exceeds the control limit specifications, immediately notify the floor production supervisor and the machine attendant of the rejected materials and have the second strip which identifies the bobbin, machine number, and pressure drops initialed by the production supervisor.

NOTE: Correct tipping paper width can be dialed in on newer model tipper. Thus making spacer clips unnecessary.

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g) Isolation procedures: All rejected bobbins for any reason must be completely checked in all phases. If a bobbin is rejected due to PD reasons bobbins before and after must be checked until good work is located and all unacceptable work is isolated.

h) The laser charts should be continuously monitored by Production Supervision and QA for any unusual variation. When questionable material is identified, it should be placed on hold until it can be re-evaluated.

i) At the end of the shift, the number of first run bobbins (bobbins that have been machined only once) tested on each machine is recorded on the control charts and the total of first run rejects is turned into production supervision and broken down by their types. All control charts and laser monitor recordings are turned into QA lab for tabulation.

3) Band Inspection

a) How are bands checked?

Bands are checked by visually examining test strips of perforated tipping paper under magnification in comparison to a predrawn scaled overlay or screen of an optical comparator. Bands that fall out of position or width are rejected and cannot be reworked/reclaimed into a complete bobbin. Bands are checked in two directions, first in reference to the edge of the paper and second, the distance between the two rows of perforation (the open mid-section of the paper). As one can establish, band width is directly related to overall specification dimensions.

b) Why check bands?

Band width and position are important because of the required distance of the perforation away from the mouth when a cigarette is being smoked and in making the filter tip of the cigarette. In applying adhesive to the tipping paper, glue may flow across all or part of the band closing the perforated holes if specification limits are not observed during tipping paper conversion. Adhesive in the band areas will change the P.D. and increases the probability that the dilution of the cigarette will not meet final smoking specifications.

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c) Overlay Design for Optical Comparator (See Attachment B5)

In dealing with magnification and precise measurements it is necessary to consider existing tolerances both with the lens and with the specifications. Lens magnification, area of screen use and expansion properties of equipment, are all used as determining factors for overlay formation.

If for example, a 10x lens was used, all specs would be multiplied by 10, provided of course, display screens are consistant. A reference line for the edge of the paper is drawn and from this line a target line is established. (This pertains to band position and width). Tolerances are then drawn on both sides of the target area.

There is a relationship between electrode gap, P.D., and band position and width. As the electrodes wear down or burn off, more distance between electrode pairs occurs which creates the necessity for higher voltage to achieve proper P.D. and an increase in the electric arch displacement as discharge occurs which causes perforation to become too narrow, too wide, or appear to to shifted in position.

4) General band information

a) Generally as long as the PD is good and the position of the band is correct any narrow band is acceptable.

b) A 3 mm band can weave 1 to 1-1/2 mm in width. A 1 mm band is allowed.

c) On a 5 mm band weaving may be as much as 2-3 mm. A 2 mm band is acceptable.

d) Electrostatic specification

Paper Width	Target	Target Range
46 mm, 54 mm	3.0 + 1.0 mm; - 1.5 mm	1.5 - 4.0 mm
50 mm, 52 mm, 62 mm 63 mm, 64 mm, 70 mm 72 mm.	5.0 - 1.0 mm; - 2.0 mm	3.0 - 6.0 mm

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

5) (The following is a list of items that can be visually observed at the DMCP.

a) Loose cores
b) Offset bobbin wind
c) Bobbin splices with bad registration
d) Bobbin splices with glue bleedout
e) Damaged bobbin due to bad pallet
f) Recessed cores.
g) Loose wind causing "telescoping"
h) Broken edges
i) Poor pallet stacking

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

3. Quality Assurance Test Station at DMCP

a. PDI Pressure Drop Instrument (Tipper)

The PDI is used to determine the permeability in cm of H20 across a given length and width of tipping paper. The determination of PD is directly related to the dilution of the finished cigarette and thus is extremely important. The PDI is adapted to the DMCP area by the use of P.M. clamp with adjustable paper holder. Special care must be taken in its calibration and insertion of test strips.

(See Attachment B6 & B7) for calibration of both the old and modified PDI's.

b. Optical Comparator

This is a device used to easily observe the band positioning of perforated test strips. Its principle of operation is a light source cast through a lens causing magnification of the desired area onto an overhead screen. Care must be maintained to use the proper brand overlay per paper size for accurate observations. (See Attachment B8)

c. Control charts are used to manually record and chart inspection data.

See the following Attachments for:

Discussion of Control Charts - B9
Example of x Chart - B10
Example of Chart - B11

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QA TECHNICIAN RESPONSIBILITIES

DETERMINE ACCEPTABILITY OF PERFORATED MATERIALS

-PRESSURE DROP
-BAND POSITION
-VISUAL OBSERVATIONS

COMMUNICATION

-DEFECTIVE BOBBINS
PRODUCTION
Q.A.
-TREND ANALYSIS BY MACHINE

CONTROL CHARTS

-PLOT DATA
-INTERPRET DATA

INSTRUMENTATION

-PROPER USE
-CORRECT CALIBRATION

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RICHMOND
ALPINE K.S. MEN. S.P.
270 (PC)

Effective Date: January 27, 1981

ATTACHMENT B2

SPECIFICATION FOR P.M. CONVERTED PERFORATED TIPPING PAPER FOR

ALPINE KING SIZE MENTHOL S.P.

BRAND: ALPINE KING SIZE MENTHOL S.P.

TIPPING PAPER: 52mm x 3200m White (WTA); P.M. Material Code 12-542-A

FINISHED TIPPING PRODUCT CODE: 12-543-A

TYPE OF PERFORATION: Electrostatic

PERFORATION R.T.D.: 6.5cm ± 2.0cm @ 17.5 cc/sec. on Modified P.M. Head

BAND LOCATION:

A)	DISTANCE BETWEEN PERFORATIONS:	24.0mm ± 1.0mm
B)	PERFORATED BAND WIDTH:	5.0mm ± 1.0mm
C)	EDGE OF PERF. BAND TO EDGE OF TIPPING PAPER:	9.0mm ± 1.0mm

PREPARED BY: Debbie J. Morgan

APPROVED BY: James L Myracle
OPERATIONS SERVICES

/dyd

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

ATTACHMENT B3

Effective Date: August 19, 1982

SPECIFICATION FOR P.M. CONVERTED TIPPING PAPER FOR B&H LIGHTS 100'S REGULAR S.P./F.T.B.

BRAND: B&H Lights 100's Regular S.P./F.T.B.

TIPPING PAPER: 72mm x 3200M White Pre-print (EC 134); P.M. Material Code 12-714-A

FINISHED TIPPING PRODUCT CODE: 12-715-A

TYPE OF PERFORATION: Laser

PERFORATION R.T.D.: 1.9 cm ± 0.3 cm @ 17.5 cc/sec. on Modified P.M. Head

NUMBER OF ROWS: 2

HOLES/INCH/ROW: 35 to 45

BAND LOCATION:

A)	DISTANCE BETWEEN PERFORATIONS	24.0mm ± 1.0mm
B)	PERFORATED BAND WIDTH	1.5mm ± .5mm
C)	EDGE OF PERF. BAND TO EDGE OF TIPPING PAPER	22.5mm ± 1.0mm

PREPARED BY: D. J. Morgan

APPROVED BY: _____
OPERATIONS SERVICES

/dyd

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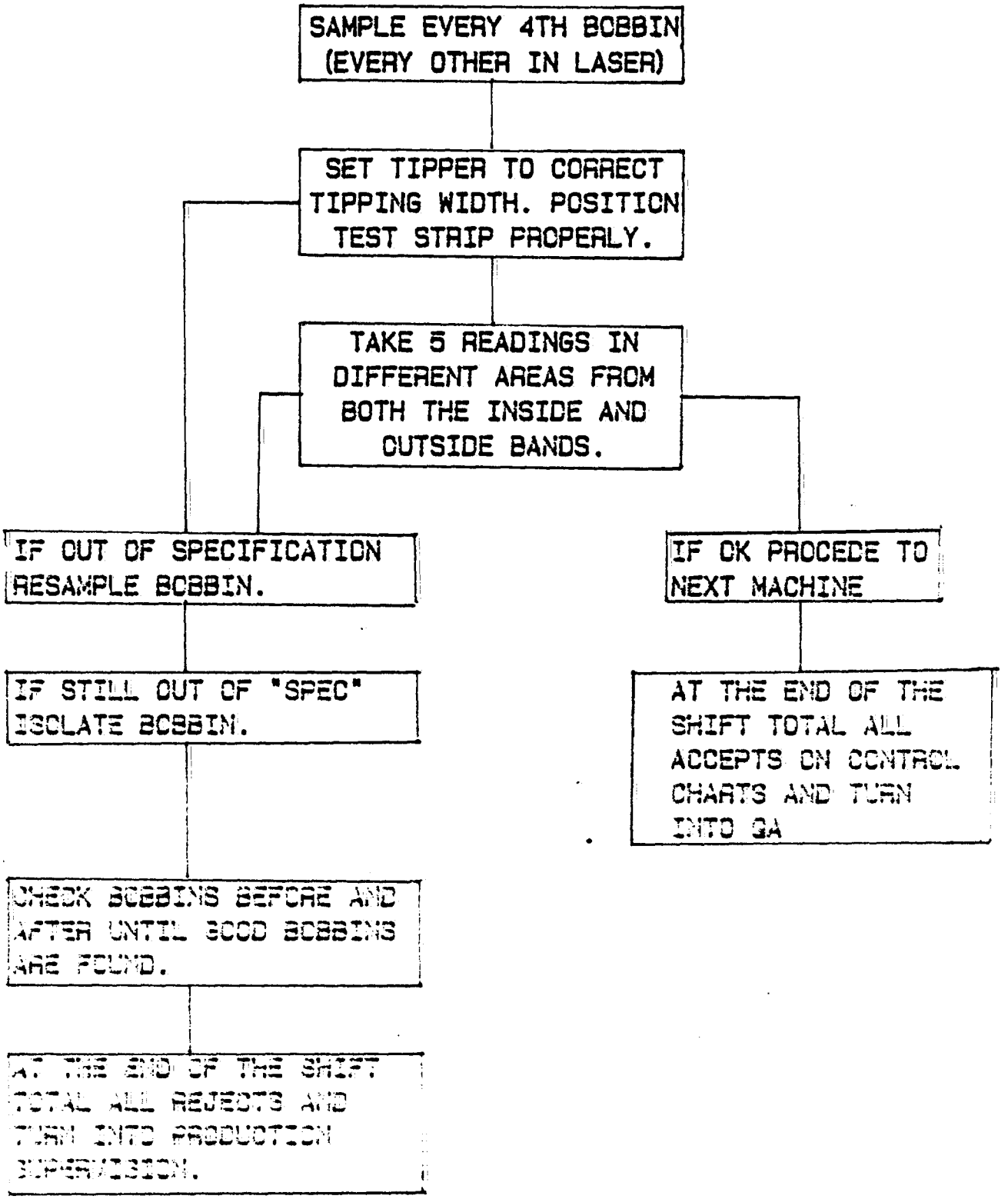
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

DMCP PRESSURE DROP INSPECTION FLOW CHART


SAMPLE EVERY 4TH BOBBIN (EVERY OTHER IN LASER)
SET TIPPER TO CORRECT TIPPING WIDTH. POSITION TEST STRIP PROPERLY.
TAKE 5 READINGS IN DIFFERENT AREAS FROM BOTH THE INSIDE AND OUTSIDE BANDS.
IF OUT OF SPECIFICATION RESAMPLE BOBBIN.
IF OK PROCEDE TO NEXT MACHINE
IF STILL OUT OF "SPEC" ISOLATE BOBBIN.
AT THE END OF THE SHIFT TOTAL ALL ACCEPTS ON CONTROL CHARTS AND TURN INTO QA
CHECK BOBBINS BEFORE AND AFTER UNTIL GOOD BOBBINS ARE FOUND.
AT THE END OF THE SHIFT TOTAL ALL REJECTS AND TURN INTO PRODUCTION SUPERVISION.

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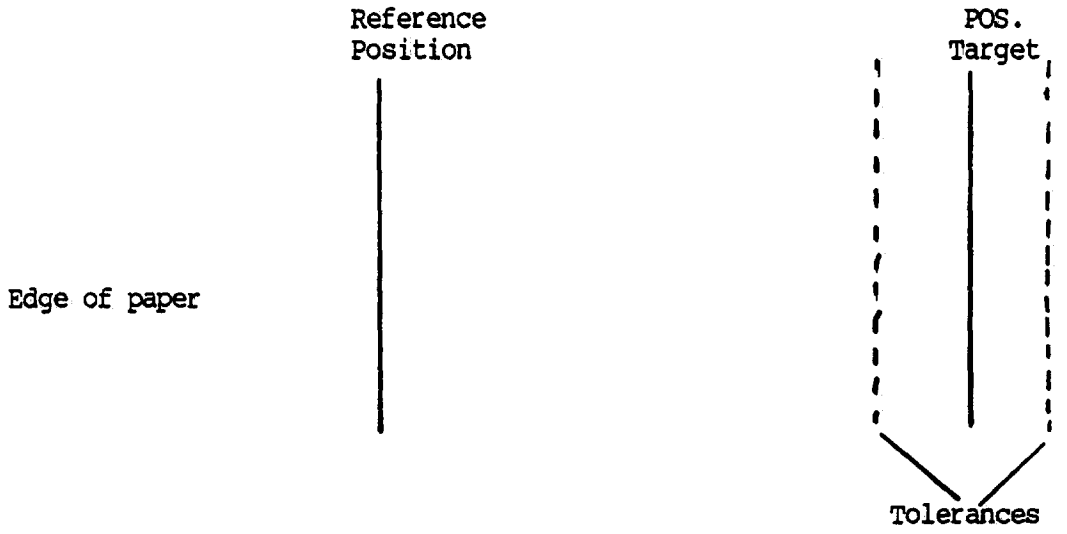
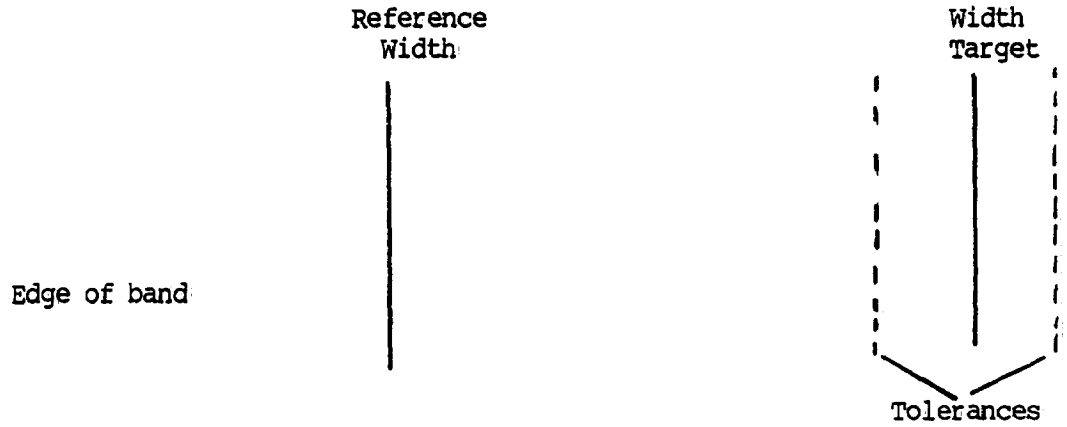
Band Position (Edge of Perforation to edge of paper).



The edge of the band nearest the edge of the paper must fall near the target, or at least within the tolerances. Tolerance is the allowable shifting of bands determined by Operational Services and R&D in relation to present maker conditions and tipping applications. If bands are initially set as near target as possible, any shifting allowed by machine guides or due to wobbly bobbins should be accomodated within the tolerances.

Band Width (the distance across one band).

Band width is also determined by using a reference line. This line is referenced to one edge of the perforated row. The other edge of the band is looked at for target determination. Notice on electrosatic perforated brands for band width that the specification may not be ± 1 (plus or minus) but + 1.0mm, - 1.5mm.



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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

ATTACHMENT B6

DMCP PDI CALIBRATION

A. Requirements and Responsibilities

1. Two(2) calibrations per shift per station will be required.
2. These calibrations will be performed by the technician asigned to the station at the start of the shift and mid-shift.

3. If the PDI is to be used for pressure drops less than .1 cm the calibrations will be performed by the specialist technician assigned to the shift.

B. Objective

To ensure that instruments are in proper calibrated working order by comparison of a known value to the instrument's function.

C. Manual Calibration (Old Style PDI)

1. Disconnect the clamp.
2. Connect and zero the manometer. (Ask your supervisor about proper reading.
3. Adjust the "zero" on the PDI until the display on the PDI reads 0.00.
4. Insert the HIGH capillary and adjust the "flow" until the manometer reads the value of the capillary (special care should be taken to read the manometer as accurately as possible).
5. Recheck zero of the manometer and capillary value several times.
6. Adjust the "span" until the capillary value is displayed on the PDI.
7. Recheck the zero and span several times and disconnect the manometer.
8. Connect the clamp and adjust the zero until the display is 0.00.
9. The calibration should be complete, use the low capillary for additional varification.

**Warning:

Sets of capillaries must be used for calibration at the station they are assigned to. If you are unable to verify your capillaries for your station, call your supervisor immediately.

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ATTACHMENT B7

D. Manual Calibration Modified ("Tipper") PDI

1. Disconnect upper cavity and connect manometer to upper port.
2. Adjust manometer to zero and electronics for upper to read zero.
3. Insert high capillary assembly - adjust upper cavity flow to capillary value and adjust span to equal capillary value.
4. Remove capillary - check zero on manometer and electronics.
5. Reinsert capillary assembly and adjust flow and span as necessary.
6. RECHECK
7. Disconnect manometer from upper port and reconnect upper cavity tube.
8. Adjust zero to read 0.00 for upper cavity - upper cavity is now complete.
9. Repeat same steps for lower cavity.

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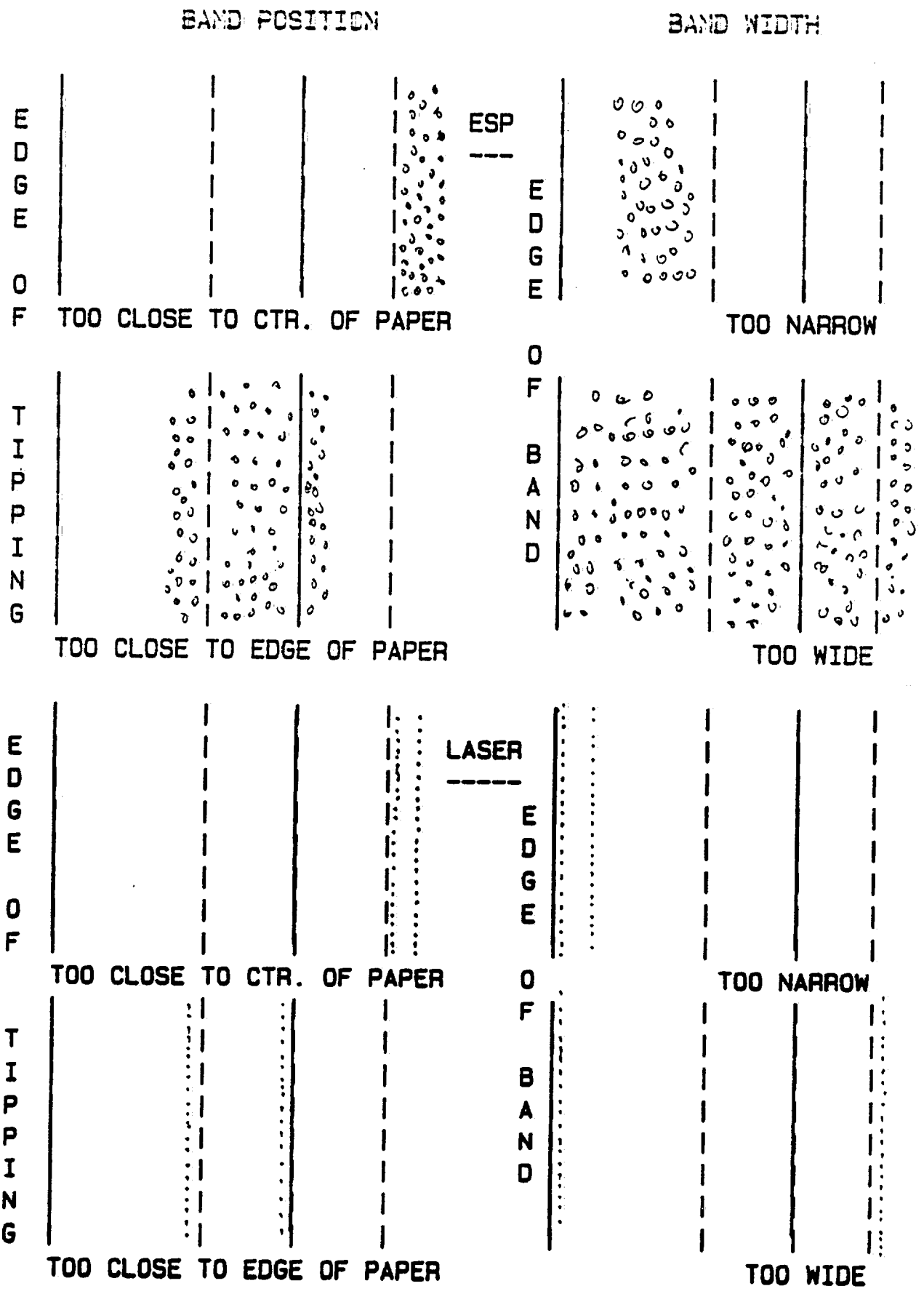
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

ATTACHMENT B8



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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

ATTACHMENT B9

CONTROL CHARTS

A. 1. Control chart - a graphical representation of the performance of a machine or the process. This concept utilizes certain guidelines or decisions to identify necessary corrections to the process to keep it within prescribed boundries or limits.

2. These limits are based on the variation of results from a group of machines producing a common product. This variation is called a standard deviation which is the measure of disperserion between the individual samples in relation to the average of the samples.

3. Three(3) times the standard deviation normally establishes the upper and lower control limits. This should relate to the specified tolerances given by Operation Services. This determines the machine's capability to produce a bobbin within acceptable limits.

4. There are two types of Control charts that will be used; the $\bar{X}$ (Averages) and the σ (standard deviation). Results from the sample strip of 5 individual readings will be recorded simultaneously for both the inside and outside bands.

A. The X chart shows where the process is centered. If the process is not stable this will be indicated by directional trends or by a erratic out of control pattern. Conditions affecting the movement on a X chart are:

1. machine settings
2. another process adjustment
3. material or parts used
4. change in operator or inspector technique
5. calibration adjustment

B. The σ chart is a modification of the Range (highest value minus the lowest value). This chart should be read and analyzed before the $\bar{X}$ chart. This measures the uniformity or consistency of the process. Generally the values in the σ chart should be as low as possible. Conditions affecting the movement on a σ chart are:

1. inexperienced operator/inspector
2. non-uniform material
3. machine in need of repair
4. loose screw or bolts
5. improper alignment

NOTE: The purpose of the σ chart is to flag unfavorable developing trends. The chart does not tell why it happened. Once the trend has been flagged then it is the joint responsibility of QA pesonnel and production supervision to determine the cause for the process being out of control and make the appropriate adjustments.

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ATTACHMENT B9

5. Adjustments necessary when:

A. On $\bar{x}$ Chart (should include resampled bobbins)

1. one x falls in "out of control zone".
2. 3 consecutive readings fall in warning zone (same side of target).
3. 6 consecutive readings fall on same side of target.

B. On σ Chart

1. any one reading falls in "out of control" zone.
2. 8 consecutive readings fall above average target line.

6. Errors to avoid in analyzing x charts

1. Intrepreting x charts when σ (std. dev.) chart not in control.
2. Relating x to a specification without looking at the distribution of the individual readings.
3. Assuming that most of the product is at or near the average.
4. An average can be made of extreme variations and is not a true indicator of the actual readings.

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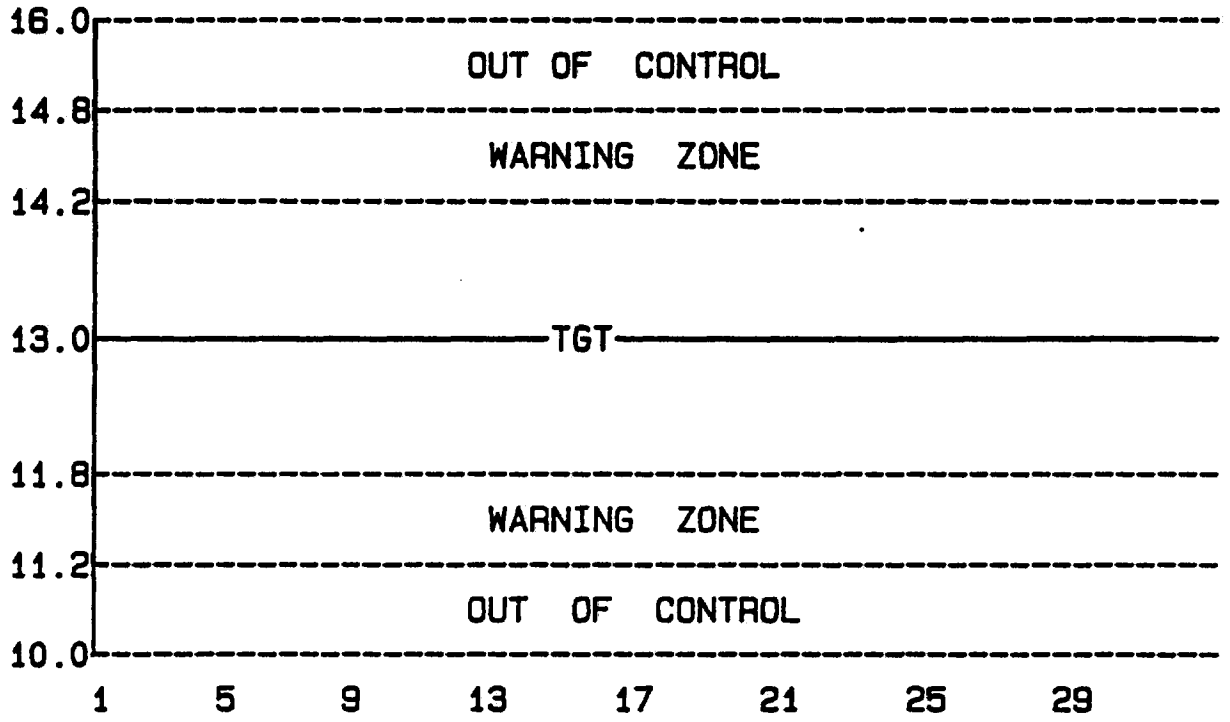
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

ATTACHMENT B10

CONTROL CHARTS

$\bar{X}$ CHARTS

INSIDE/
OUTSIDE 1 Chart per [illegible]



THIS TYPE OF CHART INDICATES WHERE THE PROCESS IS CENTERED. IF THE PROCESS IS NOT STABLE IT WILL BE INDICATED BY DIRECTIONAL TRENDS OR BY AN ERRATIC OUT OF CONTROL PATTERN.

THE FOLLOWING COULD CAUSE MOVEMENT ON THE CHART ;
1.MACHINE SETTINGS, 2.A PROCESS ADJUSTMENT, 3.PARTS OR MATERIAL USED, 4.CHANGE IN OPERATOR/INSPECTOR TECHNIGUE, 5.CALIBRATION ADJUSTMENT.

ADJUSTMENTS ARE NECESSARY WHEN:
1.ONE X FALLS IN "OUT OF CONTROL ZONE
2.THREE CONSECUTIVE READINGS ARE IN WARNING ZONE (SAME SIDE)
3.SIX CONSECUTIVE READINGS ARE ON SAME SIDE OF TARGET

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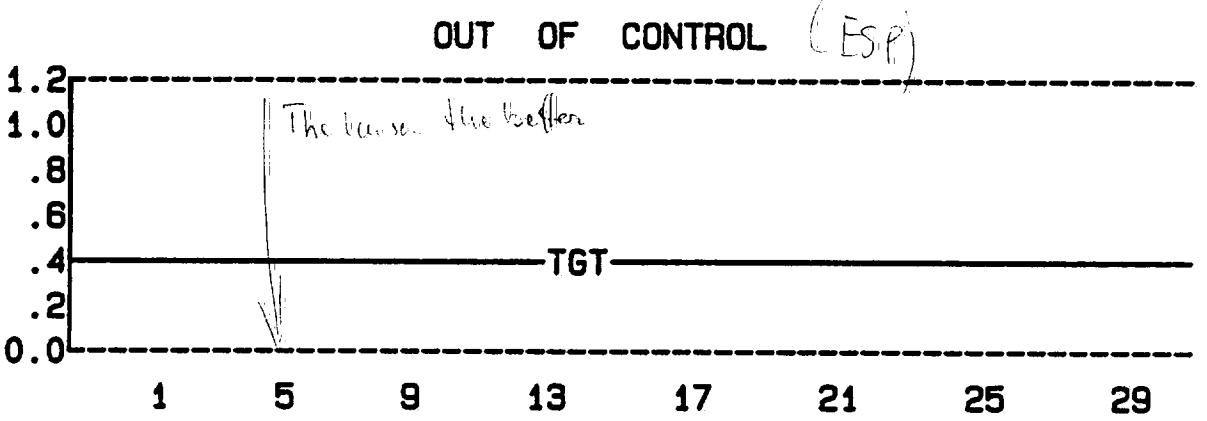
CONTROL CHARTS

STANDARD DEVIATION

INSIDE/
OUTSIDE



THIS CHART IS A MODIFICATION OF A RANGE CHART. IT SHOULD BE ANALYZED BEFORE THE X CHART. THE STANDARD DEVIATION CHART MEASURES THE UNIFORMITY OR CONSISTENCY OF THE PROCESS. GENERALLY THE VALUES SHOULD BE AS LOW AS POSSIBLE.

THE FOLLOWING COULD CAUSE MOVEMENT ON THE CHART:

1.NON-UNIFORM MATERIAL, 2.MACHINE NEEDS REPAIR, 3.IMPROPER ALIGNMENT, 4.INEXPERIENCED OPERATOR/INSPECTOR.

ADJUSTMENTS ARE NECESSARY WHEN:

1.ONE READING FALLS IN OUT OF CONTROL ZONE
2.EIGHT CONSECUTIVE READINGS ARE ABOVE TARGET LINE

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C. Dilution in Production

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

HANDLING

DILUTION

IN A

PRODUCTION

ENVIRONMENT

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C. HANDLING DILUTION IN A PRODUCTION ENVIRONMENT

1. Digital Dilution Instrument

a) Calibration procedure

1) Dilution gauge switched to "on" position.
2) Vacuum flow indicator at 15. If not internal adjustment may be necessary.
3. Check zero and 100% reading on dilution gauges as follows:

a) To check zero, clamp shut the vacuum tubing going from the dilution gauge to the encapsulator. If necessary adjust, turn dial on the gauge labeled zero until desired reading appears on display.
b) To check 100% reading, insert rubber stopper into encapsulator. If adjustments are necessary, turn dial marked span until 100 appears on the display.
c) If either or both the 0% and/or 100% reading cannot be obtained, call the Q.A. Lab before beginning testing.

4. Insert dilution capillary provided to verify its calibrated reading to actual display reading. If display readings deviates more then ±1% of the calibrated reading, make necessary internal adjustments using a water manometer.

B. Proper inserts are to be used at all times.

1) Black or stainless steel are used for 24.8 and 25.0 mm. circumference cigarettes.

2) Gold are used for 23.00 mm circumference cigarettes.

3) Green are used for 22 mm circumference cigarettes.

2. Dilution Testing -Production Procedure

a. Sample 4 cigarettes - 2 from front belt and 2 from back belt.

b. Check circumference prior to dilution check.

c. Record each dilution reading by placing a dot under the proper time column.

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d. Indicate the median by placing an (x) half way between the 2nd and 3rd dots.

e. On each inspection of 4 cigarettes subtract the lowest reading from the highest thus obtaining the range. Plot the range under the appropriate time.

f. Perform recheck if one median falls outside desired zone.

g. Perform recheck if 2 consecutive ranges fall outside desired zone.

h. Report any rechecks outside the desired zone to your supervisor.

NOTE: See Attachments C2 for an example of the dilution chart.

4. Items to Investigate When Dilution Problems Occur. (See Attachment C3)

a. Be sure dilution gauge is properly calibrated.

b. Cigarette parameters

1) Check 100 weight
2) Check circumference

c. Filter parameters

1. Correct supplies
2. Check circumference
3. Check total RTD
4. Check plug RTD

d. Tipping Paper

1. Correct supplies
2. Band location and quality (see DMCP section for details)
3. Check pressure drop (see DMCP section for details)

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

e. Glue application area

1) Correct supplies
2) Condition of adhesive (thick thin "skimmed" over)
3) Condition of gummer unit - (clean - no glue buildup)
4) Check tipping paper for proper glue application especially in the tip-to-tip area.

f. Cork Drum/Roll hand

1) Have fixer check to insure proper setting.
2) Good housekeeping

g. Patch Inspection - This can be major area of problems (Attachment C4)

1) Determine if the patch is centered, properly timed, free of glue, not in the tipping seam, perforations are in the patch area, and it is the correct size.

2) How to prepare patch for inspection

a) Cut off filter at the juncture of the tipping paper and the cigarette rod.

b) Cut tipping in the middle of the seam.

c) Apply iodine to the plug wrap side of the removed tipping paper.

d) Peel off plug wrap

NOTE: A difference in the staining effect on white tipping can be caused by its starch content.

3) Check the prepared patch for:

a) Centering and proper timing.

b) Good adhesion - especially on tipping lap.

c) Glue in the patch area blocking holes.

d) Perforations in patch area.

e) Length and width - proper size.

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4. Skip gap roller

   a) Designed to insure proper patch size.

   b) Drawings available for proper spacing on glue rollers.

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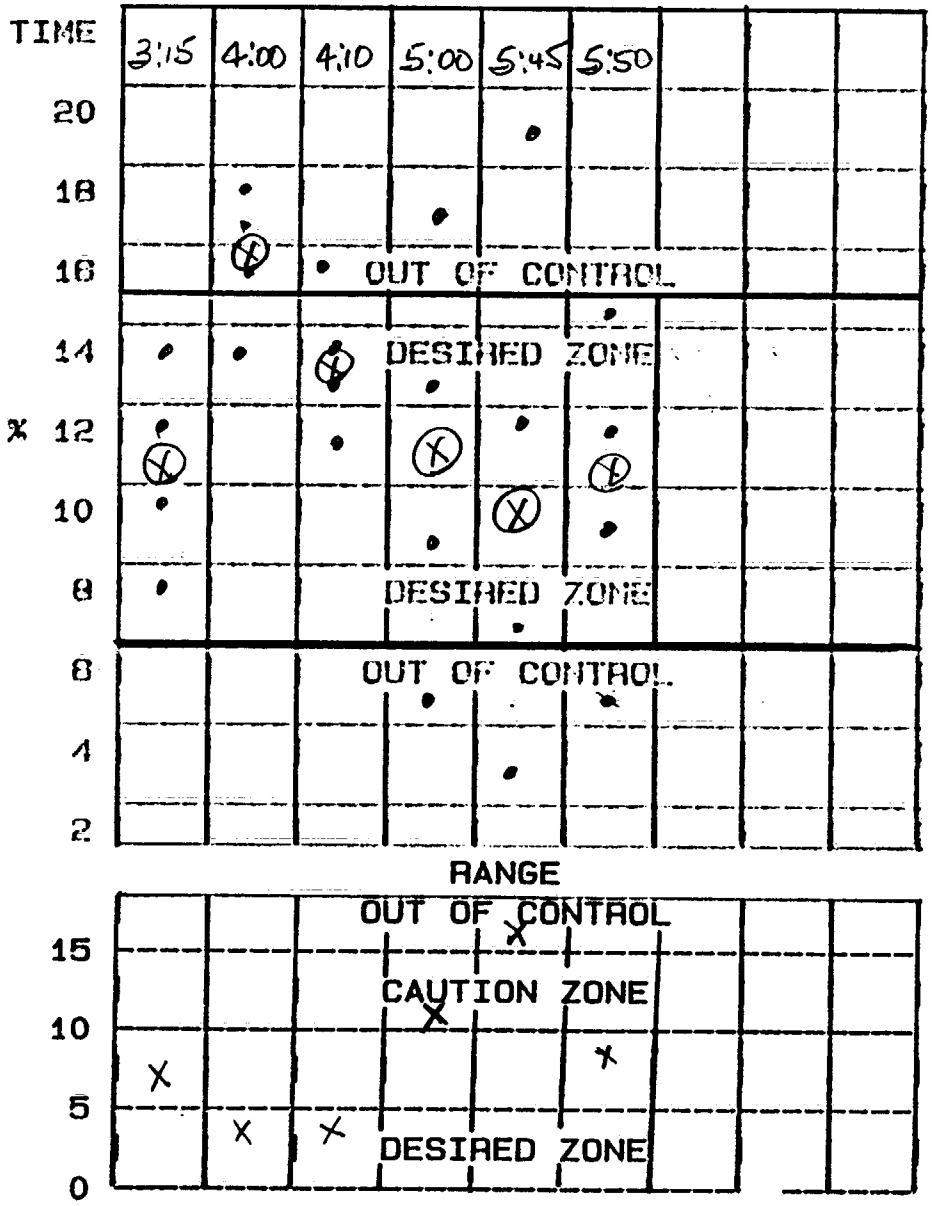
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

ATTACHMENT C2

DILUTION/VENTILATION WORKSHEET



3: 15 REGULAR INSPECTION WITH MEDIAN x BETWEEN 2ND AND 3RD CIGARETTE.

4: 00 REGULAR CHECK MEDIAN FALLS OUTSIDE DESIRED ZONE.

4: 10 RECHECK SHOWS MEDIAN WITHIN DESIRED ZONE, ACCEPT CIGARETTES.

5: 00 REGULAR CHECK WITH MEDIAN IN DESIRED ZONE BUT RANGE OUTSIDE THE DESIRED ZONE.

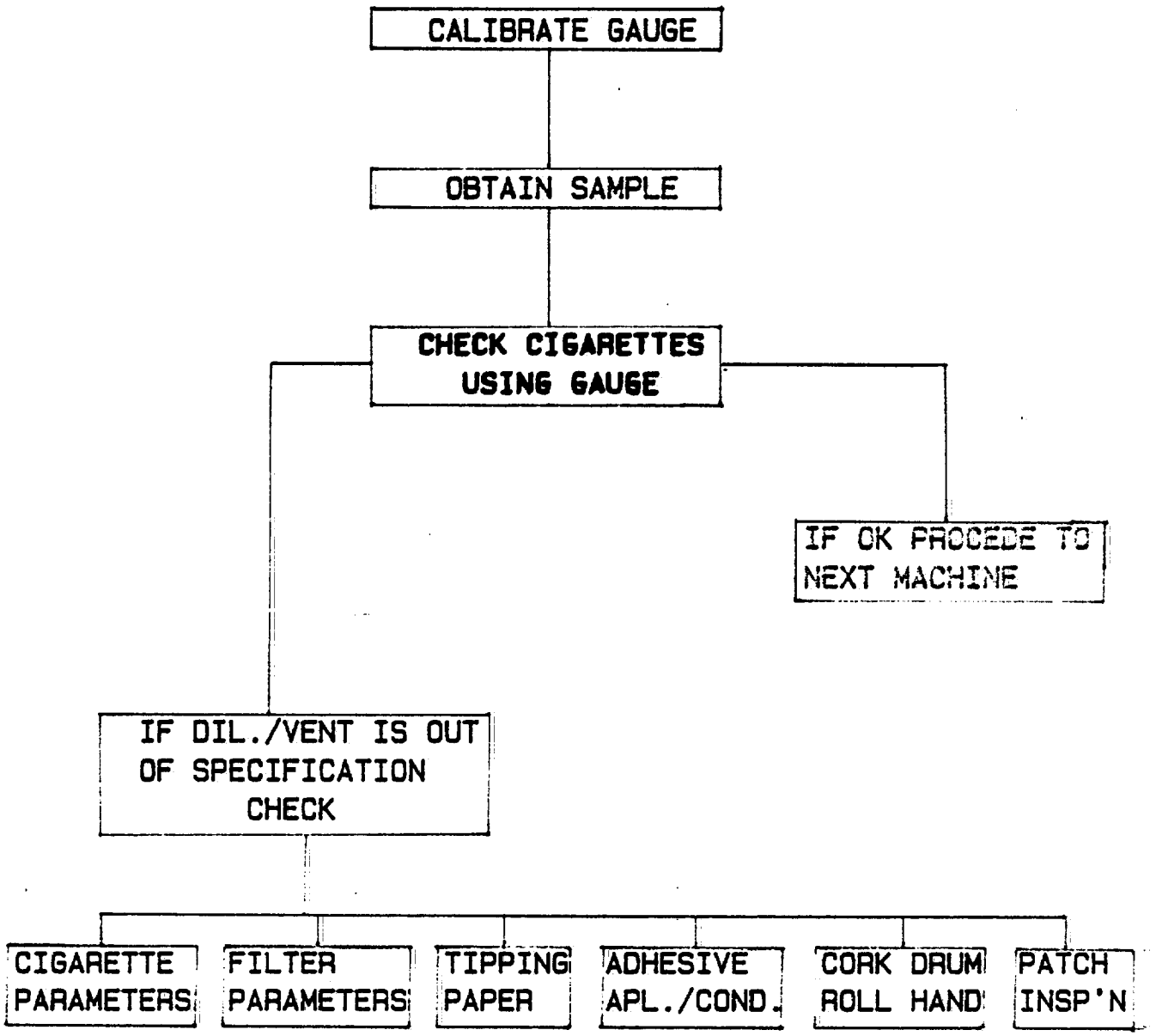
5: 45 REGULAR CHECK WITH MEDIAN IN THE DESIRED ZONE BUT RANGE OUTSIDE. SINCE THIS IS SECOND CONSECUTIVE CHECK WITH RANGE OUTSIDE DESIRED ZONE AN IMMEDIATE RECHECK IS REQUIRED.

5: 50 RECHECK WITH BOTH MEDIAN AND RANGE IN THE DESIRED ZONE.

-31-

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

VENTILATION/DILUTION CHECK



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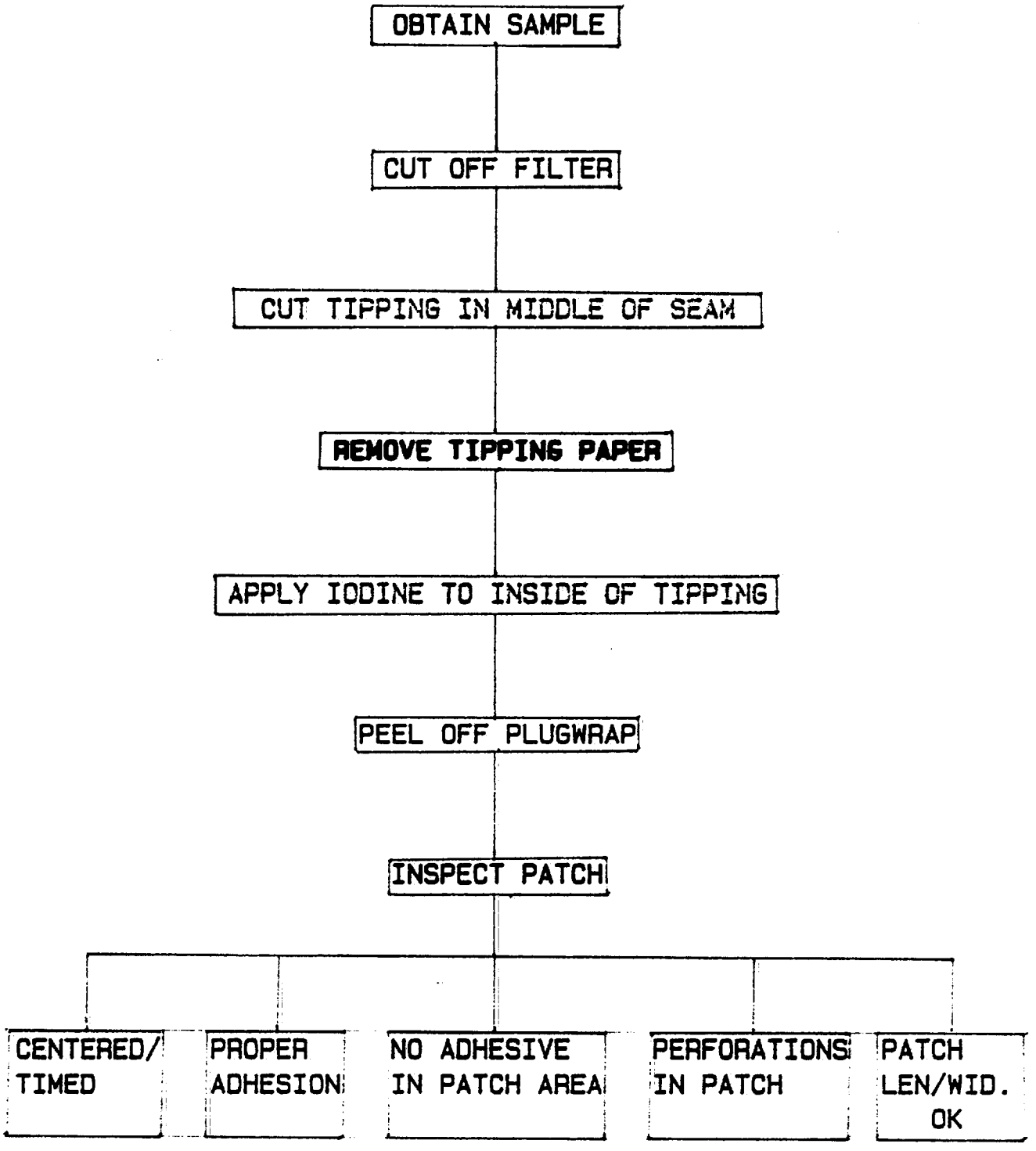
PATCH INSPECTION



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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

D. Materials Check

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

PROPERTIES

OF MATERIALS

THAT SHOULD

BE CHECKED

WHEN DILUTION

PROBLEMS OCCUR

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

D. PROPERTIES OF MATERIALS THAT SHOULD BE CHECK WHEN DILUTION PROBLEMS OCCUR

The intent of this section is not to review all the testing that can be performed on materials but to highlight those properties that could affect dilution. Additionally, the equipment used to check these properties will be discussed in this section.

1. Plug Wrap*

   a. The porosity of the plug wrap has a definite affect on the finished cigarette dilution.

      1) When dilution problems occur filter rods should be checked to insure the correct plug wrap has been used.

      2) There are three types of gauges that can be used to check the porosity of plug wrap.

         a) To check porous plug wrap a Digital Porosity Tester can be used.
         b) The Filtrona Porosity Gauge can be used to check plug wraps.
         c) The Filtrona PPM 100 can be used in testing plugwrap.

   b. Several types of plug wrap are used on ventilated cigarettes. (See Attachment D1 for examples of different plug wraps and brands they are used on.)

2. Tipping Paper*

   a. Pressure drop on preforated tipping paper is very important in obtaining the correct dilution on finished cigarettes.

      1) A Pressure Drop Instrument is used to check tipping paper for correct pressure drop. (Refer to the DMCP section for complete details on checking tipping paper pressure drop).

      2) Correct band (perforations) registration is also important in obtaining correct pressure drop. (Again see DMCP section on how to check band registration).

* See Attachment D2 for how these items affect dilution.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

3. Cigarette Paper*

a. As with plugwrap, porosity is a property of cigarette paper that can affect finished cigarette dilution.

b. The Greiner Porosity Tester is used to check the porosity of cigarette paper.

c. The Filtrona PPM 100 can also be used in testing cigarette paper.

d. Several vendor defects can affect the porosity of cigarette paper and in turn influence dilution of the finished cigarette.

1) Pin holes, thin spots and thin paper are examples of cigarette paper defects that can affect porosity.

2) A light table can be used to detect these paper defects.

e. How does cigarette paper porosity effect dilution?

1) The less porous cigarette papers are used on higher dilution brands such as Merit Ultra Lights and Cambridge. (Dilution levels around 50% or higher).

2) More porous paper is used on lower ventilation brands such as Marlboro and B&H 100's Regular. (Generally dilution levels of less than 30%).

4. Tipping Adhesive

a. Viscosity is one property of an adhesive that could affect cigarette ventilation.

1) If an adhesive is too thin it could possible "bleed" into the patch and block the perforations.

2) A Brookfield Viscometer is used to determine the viscosity of adhesives (See Attachment D3 for Viscosity testing procedures).

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

b. Good tip-to-tip (tipping lap) adhesion is important in maintaining proper dilution.

1) Viscosity testing can help determine if the proper glue is being used as well as if it meets correct specifications.

2) Solids can also help determine proper/good adhesives. (See Attachment D4 for a procedure for determining percent solid).

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Attachment D1

TYPES OF PLUG WRAP

POROUS

Vendor/Code	Brands Used On	Dilution Range
Schweitzer 17 M1	Marlboro Long Size	10±5
	B&H Lights 100's	27±5
*Schweitzer 33 M1	Marlboro Lights K.S.	20±7
*Dexter 4855	Merit King Size	30±5
**Schweitzer 260 M1	Merit Ultra Lights 100's	57±3
**Dexter 4644		

NON-POROUS

Ecusta 612	Marlboro King Size	10±5
	Marlboro 100's	10±5
	B&H 100's Regular	10±5
***Ecusta 648	Parliament K.S.	30±5
***Schweitzer 650		

* Interchangeable
** Interchangeable
*** Interchangeable

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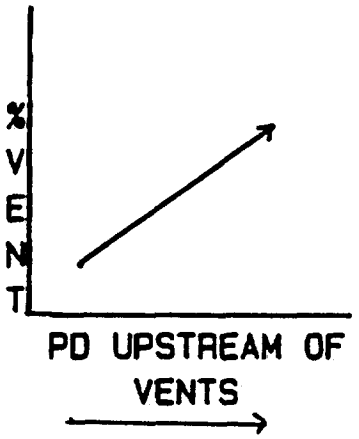
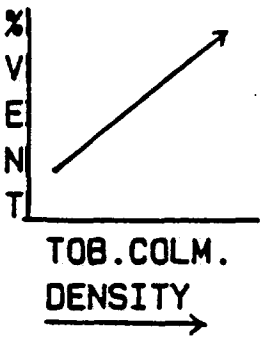
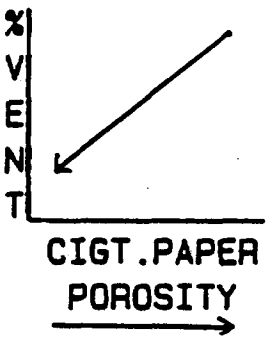
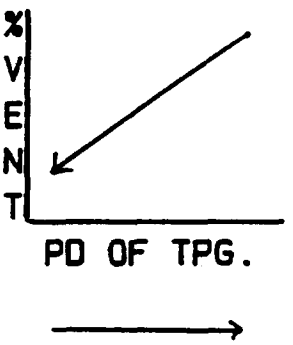
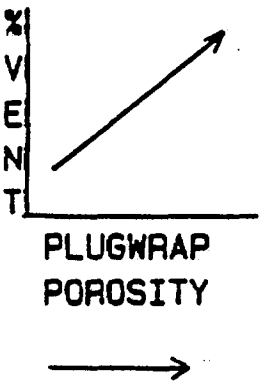
WHAT AFFECTS VENTILATION ?

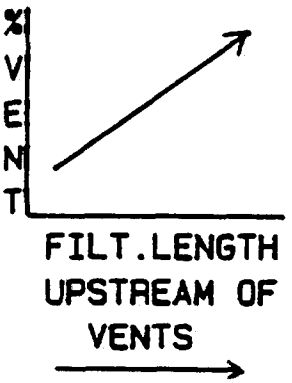


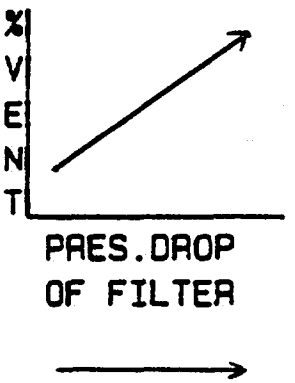












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ATTACHMENT D3

PHILIP MORRIS

U.S.A.

DIRECT MATERIAL SPECIFICATION

MAT'L. CODE:	
SUPERCEDES:	
APPLICABLE G.P.S.:	
DESCRIPTION: VISCOSITY OF ADHESIVES	DATE
	PAGE 1 OF 2

I. Scope:

1) The following method covers the determination of the viscosity of free-flowing adhesives. This procedure is applicable to adhesives ranging from 50 - 200,000 cps. and is limited to materials that have or approach Newtonian flow characteristics.

2) For adhesives not exhibiting Newtonian or near Newtonian flow characteristics, the determination of the "Viscosity Index" should be considered because shear-rate dependant flow properties are detected and a shear-rate curve may be developed from the "Viscosity Index" data.

II. Apparatus:

1) Brookfield Viscometer Model RVU, RVF, RVT, MVO, MVF.

2) Series of spindles supplied with each instrument with various sized discs covering a standard range of viscosities. Scored, warped or damaged spindles shall not be used.

3) Thermometer: A precision thermometer with graduations not greater than 0.2°C divisions.

4) Water Bath: For sample conditioning if constant temperature room is not available.

III. Procedure:

1) Condition the adhesive sample at 25°C (or temperature specified by Vendor) at least 16 hrs. in a constant temperature water bath.

2) Select a spindle suitable to the viscosity range of the adhesive and firmly fit it into the shaft extension of the Brookfield.

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3) Slowly immerse the spindle into the adhesive to the depth indicated by the groove cut into the shaft. Press down the clutch lever and start the motor by snapping the toggle switch. Then release the lever and allow rotation to continue until the pointer has reached the position where it is stationary in relation to the rotating dial.

4) Again, press down the clutch lever and turn switch off. If the pointer is not in view when the dial rests, retart motor, keeping clutch lever pressed, allow to run until reading can be obtained.

5) Readings should be 20 - 80% of the scale if optimum results are to be obtained.

Calculation: Multiply the viscometer reading by spindle constant to yield results in centipoise.

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ATTACHMENT D4

PHILIP MORRIS

U.S.A.

DIRECT MATERIAL SPECIFICATION

MAT'L. CODE:	
SUPERCEDES:	
APPLICABLE G.P.S.:	
DESCRIPTION: TOTAL SOLIDS OF ADHESIVE	DATE
	PAGE 1 OF 1

I. Scope:

The following covers the determination of the non-volatile residue of adhesive at 150°C or total solids content.

II. Apparatus:

1) Analytical Balance

2) Aluminum Moisture Dish

3) Desiccator

4) Laboratory oven-electric forced air tvpe

III. Procedure:

1) Dry, disiccate and tare aluminum moisture dish.

2) Weigh 2-3g of adhesive into the tared aluminum dish.

3) Dry in oven @ 150°C for one hour.

4) Desiccate and reweigh.

5) Calculation: $\frac{100 \text{ (Wt. of residue)}}{\text{Wt. of sample}}$ =% total solids

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TYPES

OF

INSTRUMENTATION

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E. Types of Instrumenation

1. This section deals with types of instrumentation and gauges that can be used in ventilation/dilution testing and the analysis of problems when they occur.

2. Attachment E1 contains a list of equipment with applications, model numbers and vendors.

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ATTACHMENT E1

INSTRUMENTATION

Instrument	Applications	Model No.	Vendor
Porosity Gauge	Check Plugwrap permeability	1110MAN	Filtrona
Porosity Gauge	Check plugwrap per meability and cigarette paper porosity	-	Greiner
Digital Porosity Tester	Check plugwrap permeability	-	Philip Morris
Permeability Meter	Check plugwrap, cigarette paper and Tipping paper permeability	PPM100	Filtrona
PDI "Tipper"	Check pressure drop on perforated tipping	-	Philip Morris
Optical Comparator	Check "bands" on perforated tipping	980	AM Brunning
Dilution Gauge (DDI)	Check dilution on finished cigarettes	-	Philip Morris
Ventilation Gauge	Check Dilution on finished cigarettes	VOM100	Filtrona
Circumference Gauge	Check Cigarette Circumference	50	Techmet
Circumference Gauge	Check Cigarette Circumference	TLG100	Filtrona
Viscometer	Check viscosity of adhesives	RVF	Brookfield
Balance	Check Solids in Adhesives	PK300	Mettler

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A. Porous Plugwrap

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III. PRODUCTION OF VENTILATED CIGARETTES

A. Filter Manufacture Using Porous Plugwrap

1. Hot Melt

The use of Laser, Mechanical and ESP perforated tipping papers to achieve filter ventilation has created the necessity of using porous plugwraps. Section D.-3 of the presentation discussed porous plugwrap properties and composition. The next slide compares porous plugwrap at the top with non-porous plugwrap at the bottom. The construction of porous plug is similar to tea bag construction. Water will readily flow through porous plugwraps. This presents a problem with respect to sealing seams for porous plugwrap. With the use of relatively non-porous plugwraps, starch paste and PVA adhesives have been used very successfully. Since PVA and starch paste use water as a solvent, adhesive bleed through is a problem when these adhesives are used in conjunction with porous plug wraps. This causes adhesive build-up on the machine parts, making it necessary to shut down the machine routinely and cleanup. The best alternative for seam sealing porous plugwraps is hot melt adhesive.

Hot melt adhesives are 100% solids and are applied in the molten state. By choosing the proper hot melt viscosity with regard to porosity of the plug wrap and machine speed, the bleed through can be minimized. In choosing a hot melt, the first consideration is taste and odor. Sample cigarettes are prepared and subjectively smoked against a control cigarette. If any objections are raised, the sample hot melt is rejected. As

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previously mentioned, machine speeds, plugwrap surface characteristics, and permeability of the plugwrap are important considerations in choosing a hot melt.

The next slide shows a hot melt applicator nozzle perpendicular to the paper travel. We at Philip Morris, for our KDF-2 plugmakers have determined that this is our preferred method of application. Hauni supplies a bracket to modify the mounting from 45^{o} to 90^{o}. The following slide shows the 45^{o} mounting.

The next slide shows our desired hot melt bead configuration with the nozzle perpendicular to the paper travel. With the proper hot melt, good wetting should be achieved with a minimum bleed through. The next slide shows what can happen with the nozzle less than 90^{o} to paper incline. The next slide shows the nozzle at a greater than 90^{o} incline to the paper.

Our hot melt application rate is 9 - 11 gms/min, depending on the type of hot melt and the permeability of the porous plugwrap. A typical application rate for non porous plugwrap is 1.0 grams/min for 30 meters/min plugwrap speed, or 13.33 gms/400 meters/min. Our application rate for porous plugwraps is 20 - 40% less than the application rate for conventional paper. Changing the application rate requires changing the pump drive belt and pulley.

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In summary the choice of a hot melt will be dependent upon your particular operating conditions and types and permeabilities of plug wraps. The real test remains with taste and odor evaluation and long term machineability testing. Advice is available from Operations Services in Richmond and through technical services from our suppliers. The next slide shows the adhesive requirements for hot melt adhesives. They are: 1) Increased viscosity, 2) Reduced open time.

2. Machine Considerations

The slide shows the necessary machine considerations that should be taken into account. Hot melt application temperature at the nozzle should be a maximum of 15^{o}-20^{0} C higher than the temperature in the melt tank. With the suggested application temperature in mind, changes should be made in 5 to 10^{o}C increments to determine the best application temperature. The condition of the controllers and the condition of the heaters will determine temperature settings for a particular machine.

The automatic diameter control system is installed on the combination heater cooler bar shown in the slide. The diameter is pneumatically measured using air flow. Porous plug wrap allows air to flow through the side of the filter, causing erroneous corrections in diameter to be made. It may be necessary to disconnect the automatic diameter control and make diameter adjustments manually. These adjustments would be made on the basis of circumference readings obtained from a circumference gauge that is insensitive to plugwrap porosity. In our case, we use the Laser Make.

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The slide shows the cooler bar in a raised position. The left side in the cooling section, which is cooled with chilled water. The shorter section to the right is the heater section. It is important to maintain heat here so that the hot melt does not set up prior to sealing. If heat is not maintained, hot melt will build up on the heater bar as shown in the slide. Buildup will cause a circumference problem and subsequently a machine shut down.

Paper fibers and dust from the machine may cause clogging of the vacuum system on the KDF-2 plugmaker. This will cause problems in removing filter rods from the machine to the fluted drum. The slide shows the lint sock and pan in the rear of the plug-maker. It should be inspected and cleaned on a regular basis.

The fluted drum which takes the rods from the machine is shown here. Filter rods are held in the grooves by vacuum. The passages shown here can be clogged. Low vacuum on the drum will cause the rods to hit the end stops too hard, resulting in wrinkled and crushed rods. Periodically removing the drum and cleaning it should alleviate these problems.

The adjustable damper valve in the vacuum system can also become blocked. The slide shows the valve with the cover off. The valve should be disassembled and cleaned as necessary.

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3. Machine Modifications

The slide shows changes that were made to the KDF-2 when we converted to porous plugwraps.

Changes made to KDF-2 plugmakers when converting to porous plugwraps.

1. Install a pre-heater on cooling bar.
2. Apply hot melt at a 90^{o} angle by adjusting the guns.
3. Reduce hot melt application by going to a smaller pulley.
4. Increase the vacuum on the transfer drum by means of a larger pulley on the vacuum pump.
5. Install a ceramic coated transfer drum to create friction on the drum in order to prevent damaged ends.
6. Slightly adjust the tongue, cooling bar and folders to compensate for the increased caliper of the plugwrap.
7. Make a by-pass on the hoses on the bottom of the white PVA glue pot to reduce the amount of white PVA glue applied.

4. Filter Rod Specification Changes

A further change is noted when converting from conventional to porous plugwraps. The slide shows an equation that calculates pressure drop changes at constant rod size and tow weight when the thickness of the plugwrap varies. At equal pressure drop and outside circumference, it is possible to achieve the target pressure drop with a lower tow weight. In effect, the circumference of the cylinder of cellulose acetate for the filter is less when thicker porous plugwrap is used instead of conventional non-porous wrap. In this next slide, pressure drop is plotted

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vs. plugwrap thickness at equal filter weight. The outside rod circumference is 24.65. Note that at a .03 mm plugwrap thickness, the pressure drop is approximately 342 mm, and at .09 mm plug thickness, the pressure drop is approximately 374 mm. To maintain the 342 mm pressure drop for a thicker plugwrap, tow weight would have to be reduced. The lower tow weight may be determined by using a capability curve or target line.

The following two pages in the manual, A-7 and A-8, present a Trouble Shooting guide for seam sealing porous plugs with hot melt adhesives.

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TROUBLE-SHOOTING GUIDE FOR HOT MELT SEAM SEALING

PROBLEM	PROBABLE CAUSE	PROBABLE SOLUTION
No melt applied or melt skips.	Reservoir empty	Refill hopper & wait 15 minutes for melt-down.
	Melt pump not operating.	Check to see that motor & clutch switches are "on". Check for faulty motor, transmission, or clutch.
	Temperatures low	Check thermostat adjustments & check for faulty thermostats & heaters.
	Application valve not operating.	Check air supply & solenoid-valve action. Clean valve.
	Melt bleeding out; not all applied to paper (Small amount normal)	Check nozzle-to-paper relationship. Edge of nozzle should be just inside edge of paper. Also check for proper nozzle alignment and for worn nozzle tip.
	Melt spreads too much on paper rather than staying in bead form	Clean out degraded melt or foreign matter that is clogging nozzle. Also check nozzle for wear & alignment.
	Bridging in melt hopper.	Break loose unmelted or solidified material blocking flow in hopper. Minimize this trouble by leaving only small amount of melt in hopper before long shutdowns.
Melt applied properly but not transferred to other side of paper to make seal.	Applicator valve temperature low	Adjust valve temperature to recommendation for adhesive being used. Check operation of thermostats and heaters.
	Garniture not adjusted properly.	Clean folders and tongue. Adjust garniture and tube belt.
	Insufficient melt.	Increase pump speed. Check for nozzle blockage and for low temperatures. Check for adequate movement of applicator valve.

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TROUBLE-SHOOTING GUIDE FOR HOT MELT SEAM SEALING

PROBLEM	PROBABLE CAUSE	PROBABLE SOLUTION
Poor sealing or excessive circumference variation.	Improper cooling.	Remove kinks in water lines. Adjust cooling bar and check straightness of bar surface. Check operation of heat exchanger or refrigerant system. Water temperature should be set to manufacturer's recommendation, usually 50-65°F (10-18°C) with no load on cooling bar.
	Degraded melt.	Check for degraded melt in system; clean and refill.
	Bubbles in melt at start-up.	Some bubbling is normal after shutdowns because air is drawn into system during cooling. Minimize by eliminating leaks in headers and around plugs and by leaving partial or full heat on applicator during overnight shutdowns.
	Continuous bubbling in melt.	Ruptured valve-actuator diaphragms on applicators which use them may allow compressed-air leakage into melt. Replace diaphragms.
	Garniture not properly adjusted.	Clean folders and tongue. Adjust garniture & tube belt.
	Condensation on cooling tube.	Water supply too cold. Set to manufacturer's recommendation, usually 50°F (10°C) or warmer.
Melt squirts from nozzle as hot melt valve closes.	Excessive needle travel of applicator valve.	Adjust travel to manufacturer's recommendation, usually about 1/16 inch (1.6 mm).

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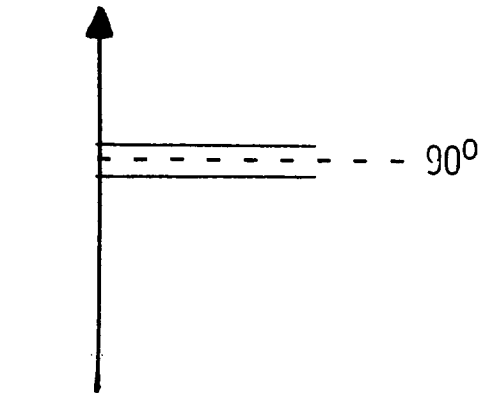
PROPER BEAD CONFIGURATION

NOZZLE INCLINATION	
HOT MELT BEAD CONFIGURATION	
GENERAL COMMENTS	GOOD SEAL, MAXIMUM WETTING, LOW BLEED THROUGH

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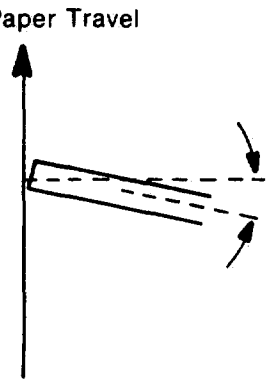
INFERIOR BEAD CONFIGURATION

NOZZLE INCLINATION



HOT MELT BEAD CONFIGURATION

GENERAL COMMENTS

Poor Wetting, Possible Throw-off on Trumpet

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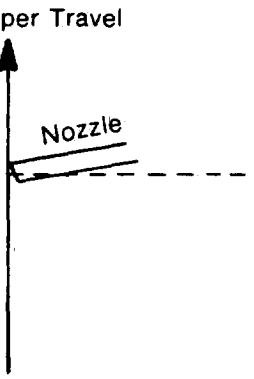
INFERIOR BEAD CONFIGURATION

NOZZLE INCLINATION



HOT MELT BEAD CONFIGURATION

Hot Melt Bead

GENERAL COMMENTS

Poor Seal Strength, Minimal Heat Capacity at Heater Bar, Good Wetting

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POROUS PLUGWRAP RODMAKING

GENERAL MACHINE CONSIDERATIONS

- NOZZLE TEMPERATURE HIGHER THAN TANK TEMPERATURE (MAX. 15 - 20° C)
- NOZZLE SET AT 90° TO PAPER TRAVEL
- MACHINE TO MACHINE TEMPERATURE SET-UP MAY BE DIFFERENT DUE TO TYPE OF CONTROLLERS, AGE AND CONDITION OF HEATERS
- HOT MELT FLOW IS FROM 9 G/MIN TO 11 G/MIN AT 400 M/M FOR HOT MELTS P.M. U.S.A. USES.
- ELIMINATION OF KNIFE BUILD-UP PROBLEM SHOULD INCLUDE KNIFE CLEAN-UP BETWEEN EACH HOT MELT ADJUSTMENT
- TO OPTIMIZE TEMPERATURES, ADJUST IN 5-10° C INCREMENTS.

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CHANGES MADE TO KDF-2 PLUGMAKERS WHEN CONVERTING TO POROUS PLUGWRAPS

1. INSTALL A PRE-HEATER ON COOLING BAR.
2. APPLY HOT MELT AT A 90° ANGLE BY ADJUSTING THE GUNS.
3. REDUCE HOT MELT APPLICATION BY GOING TO A SMALLER PULLEY.
4. INCREASE THE VACUUM ON THE TRANSFER DRUM BY MEANS OF A LARGER PULLEY ON THE VACUUM PUMP.
5. INSTALL A CERAMIC COATED TRANSFER DRUM TO CREATE FRICTION ON THE DRUM IN ORDER TO PREVENT DAMAGED ENDS.
6. SLIGHTLY ADJUST THE TONGUE, COLLING BAR AND FOLDERS TO COMPENSATE FOR THE INCREASED CALIPER OF THE PLUGWRAP.
7. MAKE A BY-PASS ON THE HOSE ON THE BOTTOM OF THE WHITE PVA GLUE POT TO REDUCE THE AMOUNT OF WHITE PVA GLUE APPLIED.

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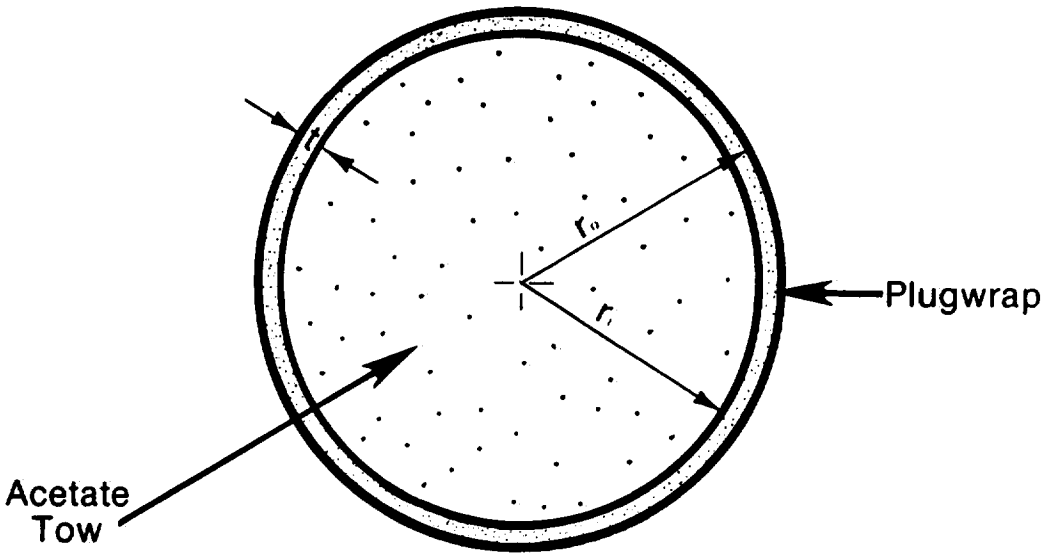

r_o = outside rod radius
r_i = tow only radius
t = plugwrap thickness
C_o = outside rod circ.
C_i = tow only circ.

At constant rod size and tow weight

$$E\Delta P_2 = E\Delta P_1 \left(\frac{r_o - t_2}{r_o - t_1}\right)^{-5.6037}$$

Where 1 and 2 denote plugwraps 1 and 2

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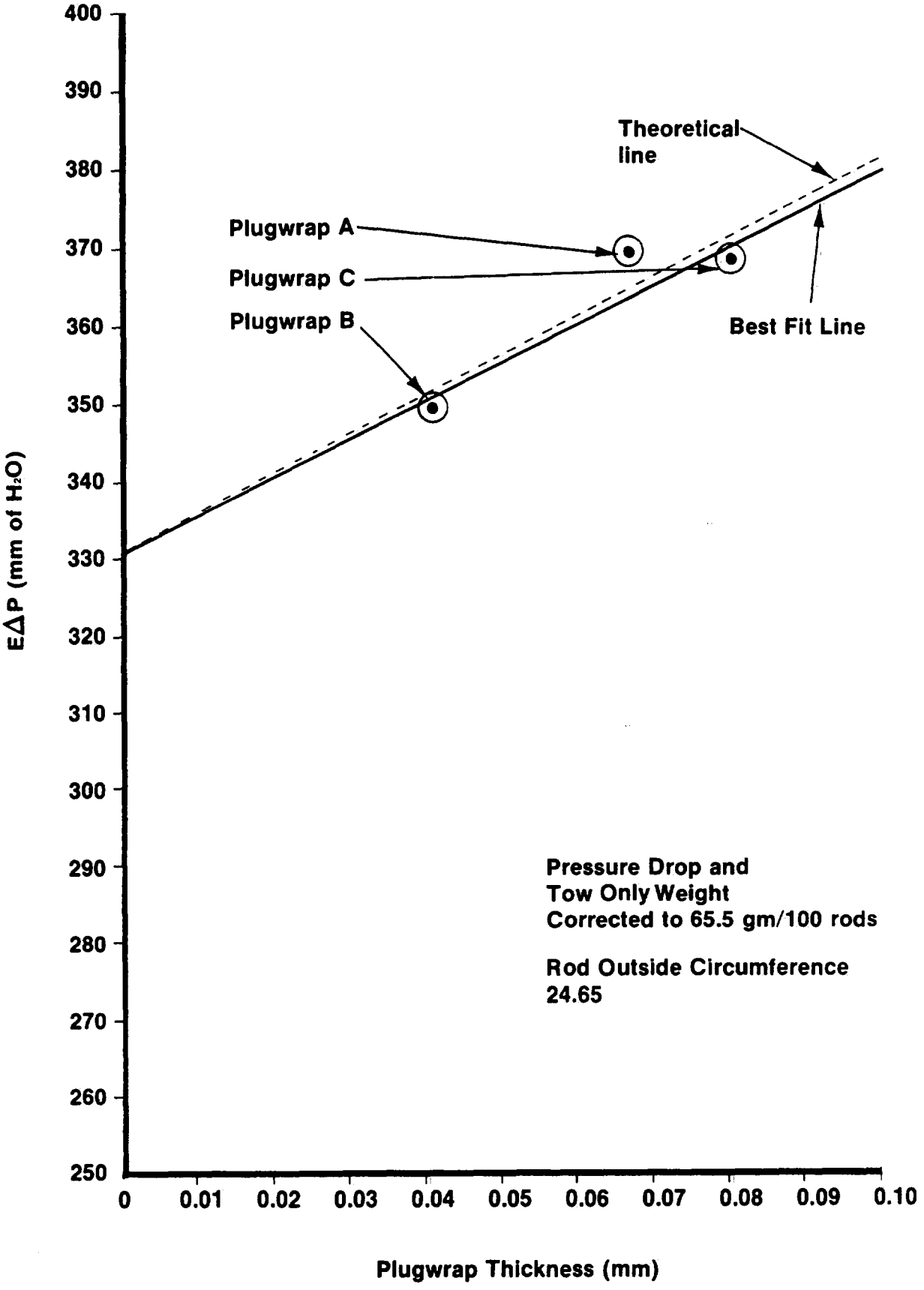
PLUGWRAP THICKNESS VS. PRESSURE DROP



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KDF-2
HOT MELT

Technical Data and Settings

Reservoirs

Reservoir (1) can accommodate up to 4.5 kg of granular adhesive.

Reservoir (2), for the inner adhesive, has a capacity of about 13 litres.

Melting Chamber

The two heaters in the melting chamber each have an output of 180 watts.

The temperature in the chamber is set on thermostat u 12. The operational temperature should be about 130°C.

Feed Pump

A solenoid clutch, controlled by the thermostat, is incorporated in the feed pump drive. The thermostat must be set (approx. 100° - 110°) so that the drive to the pump is only engaged when the granular adhesive in the melting chamber is liquid.

Applicator Nozzle for Seam Sealing

The applicator nozzle is fitted with two heaters each with an output of 200 watts.

The operational temperature for the applicator nozzle is set on thermostate u 13 and should be 170° max.

The applicator nozzle can be shifted axially using a set screw.

The course of travel of the paper web to the nozzle tip is set by means of two hard metal pins.

The paper should run vertically past the nozzle tip, touching it lightly.

The compressed air needed to actuate the cut-off needle is controlled by a solenoid valve.

The retaining pressure for the needle should be 3 bar (approx. 3 kp/cm^2) overpressure and should not exceed this.

Applicator Nozzle for Inner Gluing

The applicator nozzle can be set laterally in relation to the course of travel of the paper web by loosening the knurled screws. Set it so that the paper presses lightly against the nozzle as it runs past.

The opening and closing of the nozzle is controlled by the solenoid valve incorporated in the starting and stopping circuit of the machine.

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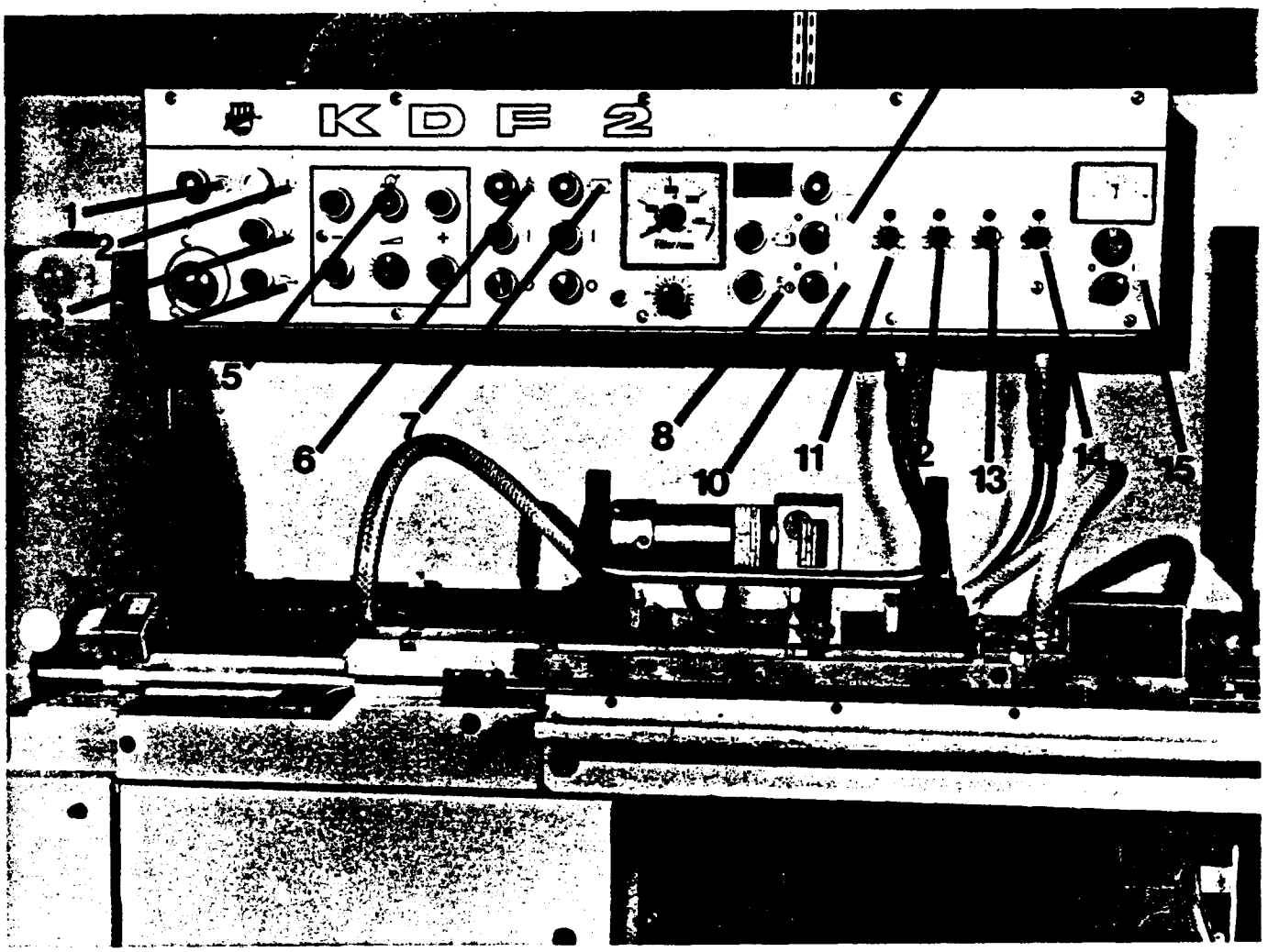

1. "Main" Pilot Lamp
2. Machine Operational Pilot Lamp
3. Knife Advance Push Button
4. Measuring Tube Cleaning Push Button
5. Diameter Control Indicator
6. Auxiliary Drive Push Button
7. Machine Start Push Button
8. Bobbin Swivel Control
9. Heater Rotary Switch
10. Glue Nozzle Rotary Switch
11. Glue Nozzle Thermostat
12. Heated Feedway Thermostat
13. Feed Pump Thermostat
14. Hot Melt Chamber Thermostat
15. Cooling Bar Heater Rotary Switch

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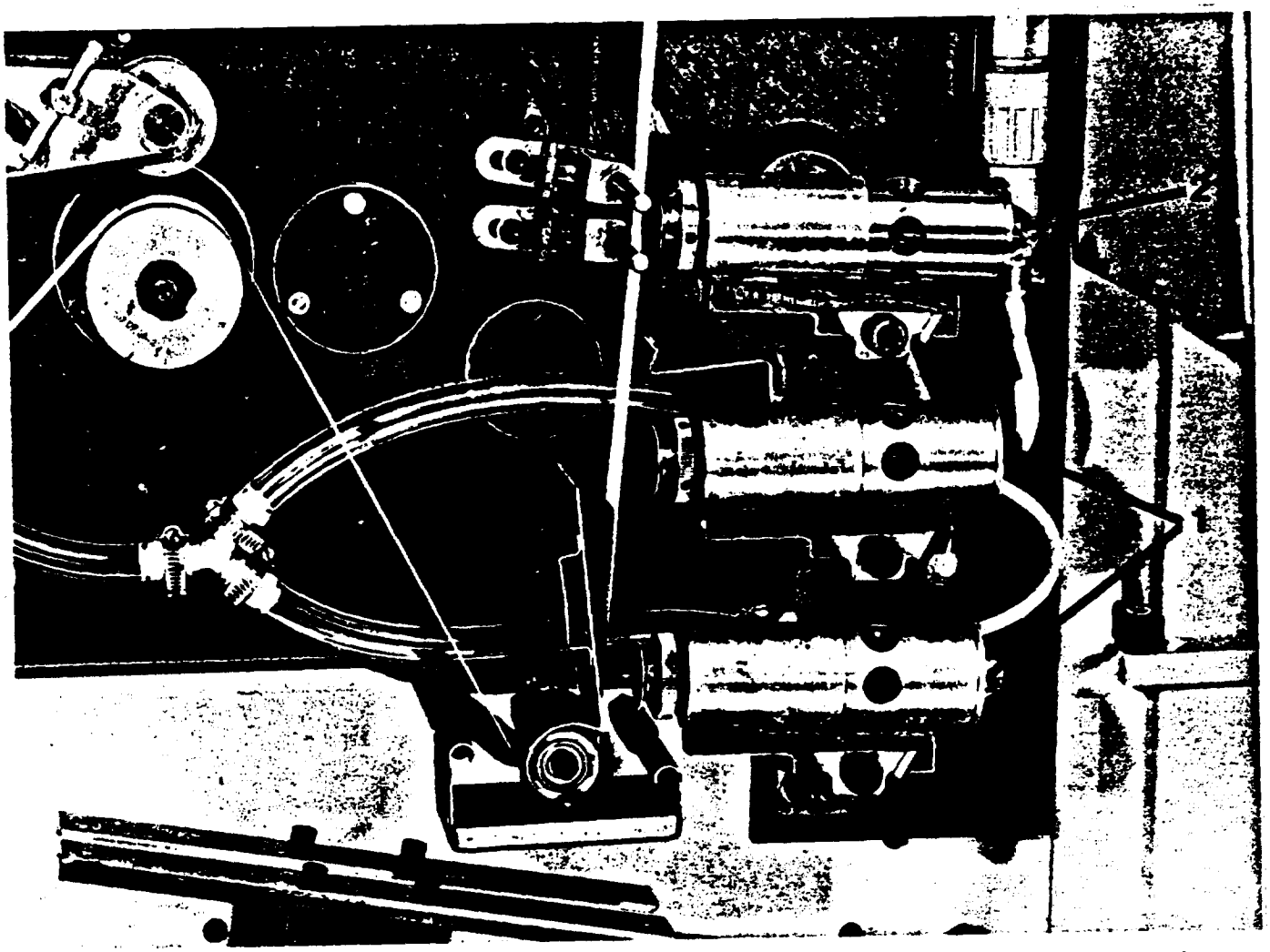
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000



1. White Glue Applicators
2. Hot Melt Applicator

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B. Skip Gap Rollers

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TECHNISCHE INFORMATION

Hauni-Werke Körber & Co. KG Hamburg

TI 004/81

FILTER ASSEMBLER MAX S/MAX 80
Subassembly 46 FA

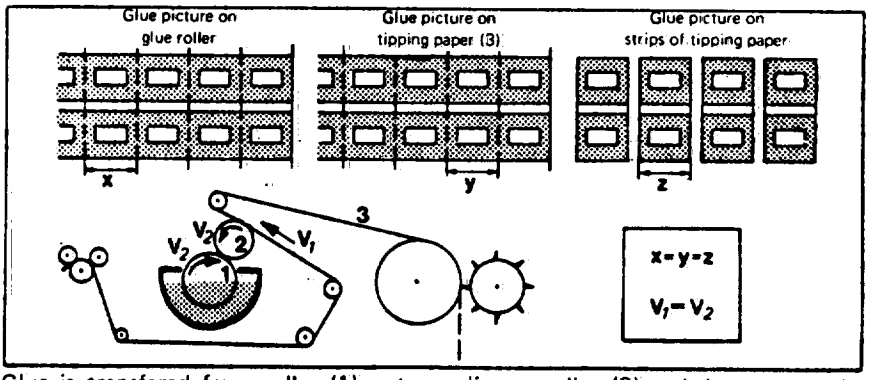
Synchronized PRINT-SKIP-TIP glueing unit
Special equipment: Subsequent installation, commencing with Machine No. 447, is recommended.

A special SKIP-TIP glueing unit is required for producing cigarettes with dilution zone, using highly porous or pre-perforated filter paper.

With application of the new PRINT-SKIP-TIP glueing unit, the pre-determined degree of dilution is maintained through an exact formation of the glue-free zone, even at high speeds. Besides, setting up has been simplified considerably, as opposed to existing synchronized glueing units and is now superfluous when re-assembling the glueing unit after cleansing (automatically correct position of glue-free zone on tipping paper). Intervals between maintenance have been extended.

Application of the PRINT-SKIP-TIP system avoids machine contamination (even with highly porous tipping paper, glue is not wiped through the paper pores) and the pre-determined degree of dilution is maintained exactly (no splashes of glue or badly formed glue pictures at high speeds).

The following sketch explains the operating mode of the synchronized PRINT-SKIP-TIP glueing unit:



Glue is transfered from roller (1) onto applicator roller (2) and thence onto the tipping paper (3).
Since the speed of the tipping paper (v_1) equals that of the circumferencial speed of the glue roller and of the applicator roller (v_2), the glue picture is printed at the ratio of 1:1 onto the paper: PRINT-SKIP.

The delivery programme of the glueing unit comprises one glue roller, one glue applicator roller with the respective drive gears, one glue pot with retainer bridge and one cleaner plate. Glue roller, applicator roller, drive gears and retainer bridge are garniture parts. The mechanical conversion is kept to a minimum.

When ordering, please quote the TI Number and the Machine Type and Number.

2025445687

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TECHNISCHE INFORMATION

Hauni-Werke Körber & Co. KG. Hamburg

TI 016/78

FILTER ASSEMBLER MAX S
Subassembly 46 FA

New Glueing Device for Mild Cigarettes (Wipe-Skip-Tip principle)
– Special equipment –

The manufacture of mild cigarettes with highly porous or preperforated tipping material demands a special glueing device which has become known as Skip-Tip or synchronized glueing.

The new Skip-Tip unit also fulfils the demands according to a specific kind of glue application, in this case, however, the glue is not "printed" onto the tipping material but wiped on by the transfer roller in an exactly calculable process. The advantage of this process is that setting up and operating costs are considerably reduced when changing the cigarette diameter or the length of the tipping material.

After a speedily carried out, minor conversion, this special glueing device can be operable without changing the gearing.

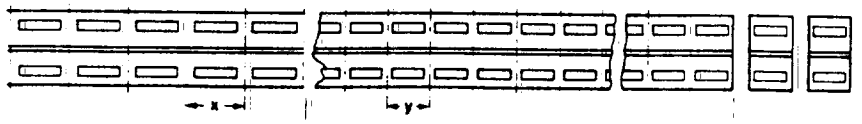
The delivery programme of the subassembly comprises a glue roller, two driving wheels, a tipping material direction-change device and, depending on the state of the machine equipment, a gear motor.

Subsequent installation, commencing with MAX S, machine No. 1, is possible.

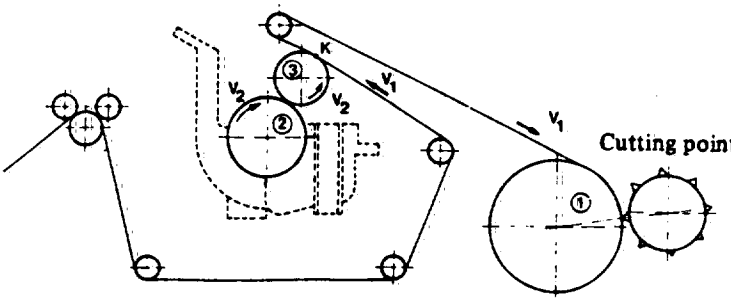
For mode of operation of the new glueing device, please refer to functional description below.

V_1 is the speed of the tipping material. It is dependent on the number of pieces of paper required and their length.

V_2 is the circumferential speed of glue roller (2) and transfer roller (3). It is dependent on the number of pieces of paper required per minute. This is always larger than V_1.



Glue pattern on glue roller | Glue pattern on tipping material



From the speed difference it follows that the transfer roller has travelled path "X" in the same time that the tipping material has been advanced by distance "Y".

Through this circumstance, the glue pattern of length "X" is wiped together to length "Y" of the desired glue area of the tipping material at contact point "K".

Since there is a constant speed ratio between tipping roller (1) and the glue roller, the cut is always made at the same point, once set.

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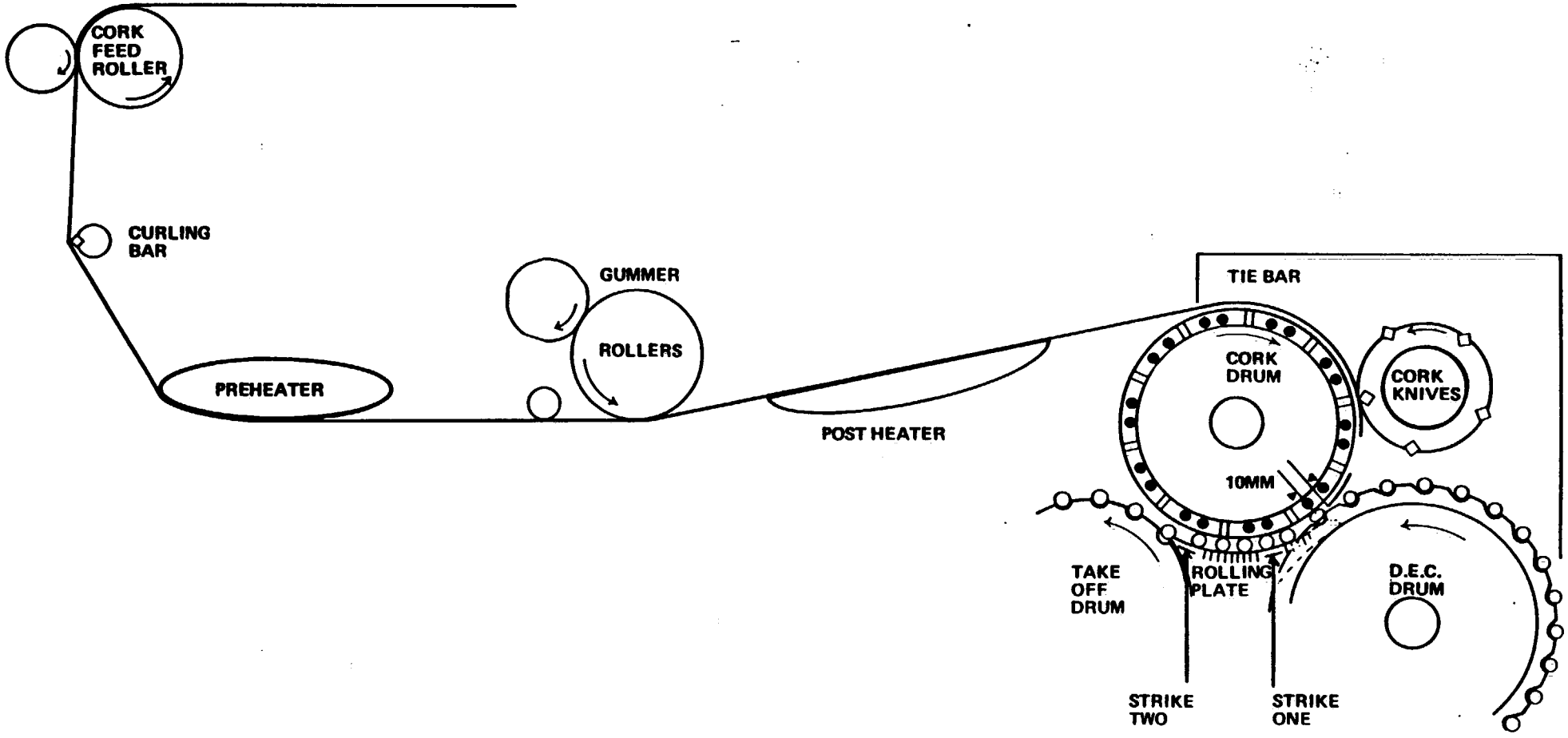
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000



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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

TIMING KNIFE AND PATCH ON PA-8
(Optional: Reference may change; if so,
see PA-8 tipping application book.)

1. Turn machine so take off drum retaining screws for vacuum valve are in 6:00-12:00 o'clock position.

2. Go to back of machine and center 5mm allens in elongated slot in cork drum drive gear.

3. Place piece of tape on cork drum, 1st insert to left of tie bar.

4. Turn machine to where 2nd row of holes, to right of work drum insert, line up with tie bar.

5. Go to back and loosen 4-5mm allens on tipping knife drive gear. Turn tipping knife gear c.c.w. Tighten 5mm allen. Should be on left side of gear slot.

6. Turn machine so 1st row holes right of insert line up with tie bar.

7. Go to back, loosen 4-5mm allens and turn tipping knife gear gently c.w. until it stops. Tighten 4-5mm allen bolts.

8. Turn machine forward until take off drum is on 3:00-9:00 o'clock. Back machine until take off drum is in 6:00-12:00 position. Check cut on tape.

9. Tear lead edge of tape off and place 37mm length tape from knife cut forward.

10. Rotate machine forward to retainer screws on take off drum are approximately 3:00-9:00 position. Center pips on rolling plate fingers to center of flute on double end closer drum.

11. Go to back, loosen allens in cork drum drive gear back of take off drum.

12. Center leading edge of 37mm tape to center of pips and flute of double end closer drum.

13. Go to back and tighten 4-5mm allen bolts in cork drum drive gear.

14. Check setting using filters.

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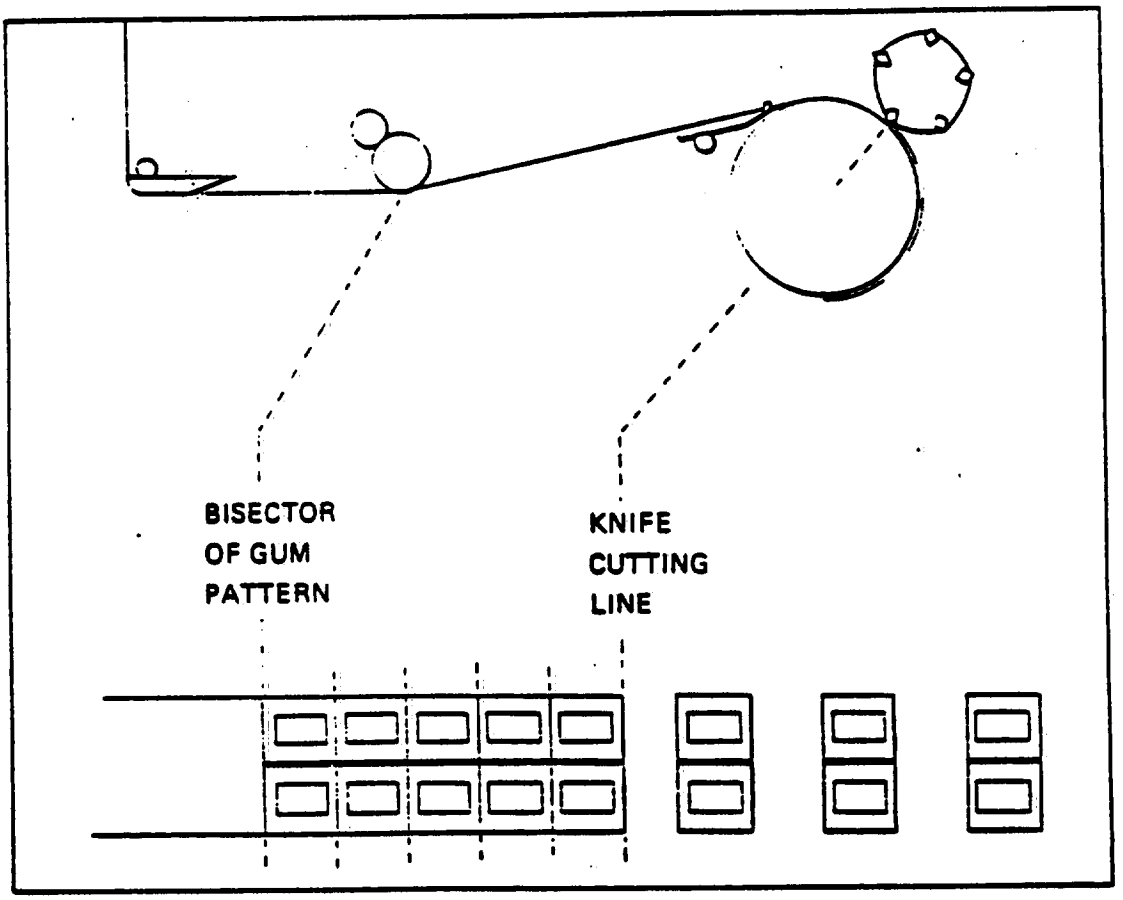
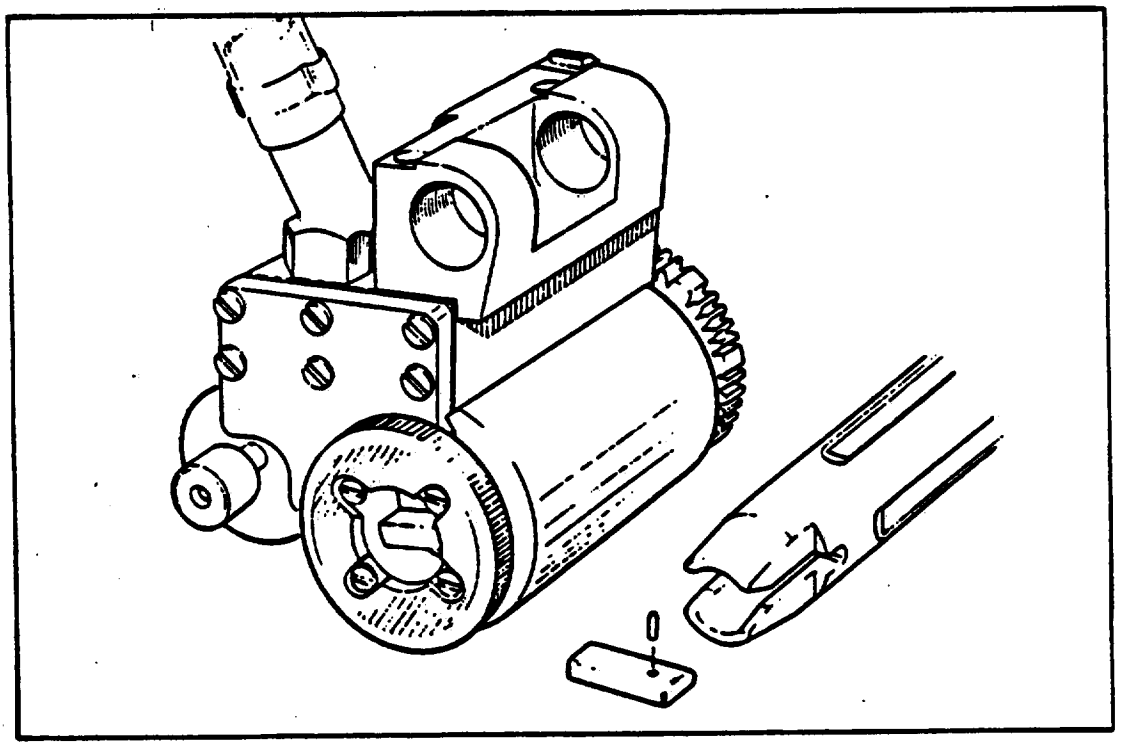
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000





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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Time Patch (Tipping):

1. Remove brush cover and brushes.
2. Remove scraper and pad support.
3. Break nut on tipping knife (22mm wrench) counterclockwise. Use scale on underside to keep knife from turning.
4. Remove front support bracket and drum. (3-8mm allen and 4-6mm allen).
5. Mark 1-2mm ahead of hole pattern on tipping drum.
6. Mark 27mm counterclockwise from first mark. (Depending on tipping circumference).
7. Replace tipping drum and front support bracket. Turn lead mark to centerline of swash drum-tipping drum.
8. Disengage machine.
9. Turn slitter knife on to prevent breaking the knife.
10. Hold tipping drum on centerline and turn machine till centerline of flute on swash drum lines up with lead mark on tipping drum. Replace bolts.
11. Manually turn tipping drum till trailing mark is brought into contact with centerline of knife blade.
12. With plugs and tipping paper in machine, the leading edge of tipping paper should be on centerline of plug when plug is on tipping drum-swash drum centerline. Lock nuts. (Using paste on plug, 2.5-3.0mm tag on.)
13. Replace brushes, brush cover, and scraper-pads.

Remove and Replace Tipping Knife:

1. Remove brush and brush guard.
2. Remove tipping knife nut.
3. Remove front support bracket.
4. Remove tipping knife washer and knife housing.
5. Replace knife housing and washer.
6. Replace front support bracket.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

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7. Replace knife nut.

8. Rotate tipping drum to where trailing mark and knife engages. Lock tipping nut.

9. With knife - tipping drum on centerline, loosen 2-8mm and 1-6mm allen and adjust thumb screw for a knife - tipping drum pressure. Lock 2-8mm allen. Rotate knife off centerline then lock the 6mm allen.

Vacuum Release at Rail Lip:

1. Turn knife and vacuum on.

2. Turn selector switch to hand position.

3. Set roll plate lip to centerline of flute on rolling drum.

4. Loosen vacuum control 3-6mm allen (leave one tight) rotate clockwise always.

5. Drop roll plate. Place plug in flute of rolling drum. Turn vacuum control counterclockwise till plug drops.

6. To check, drop roll plate, place plug in flute of rolling drum, rotate slowly till plug drops, raise roll plate and see if lip is in centerline of rolling drum flute.

Set Finger and Time Alignment Drum:

1. Remove cover of alignment drum.

2. Remove cradle.

3. Remove rolling drum (4-6mm allen).

4. Loosen 2-6mm allen on roll block mount. With feeler gauge obtain an even gap between roll block fingers and alignment drum pips. (Approximately .047).

5. Lock 2-6mm allen. Be sure roll block is back against the mount when tightened.

6. Replace rolling drum, use 7.9 or 8.0mm rod to obtain proper timing between rolling drum and intermediate drying drum. (Obtain as loose a fit as possible between the two.)

7. Remove rods.

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8. Time alignment drum to rolling drum (4-5mm allen). Place a plug in flute of rolling drum, rotate flute-with-plug to centerline of rolling drum-alignment drum. With plug in this position rotate the alignment drum pips to trail approximately .5mm behind plug.

9. Lock allen bolts.

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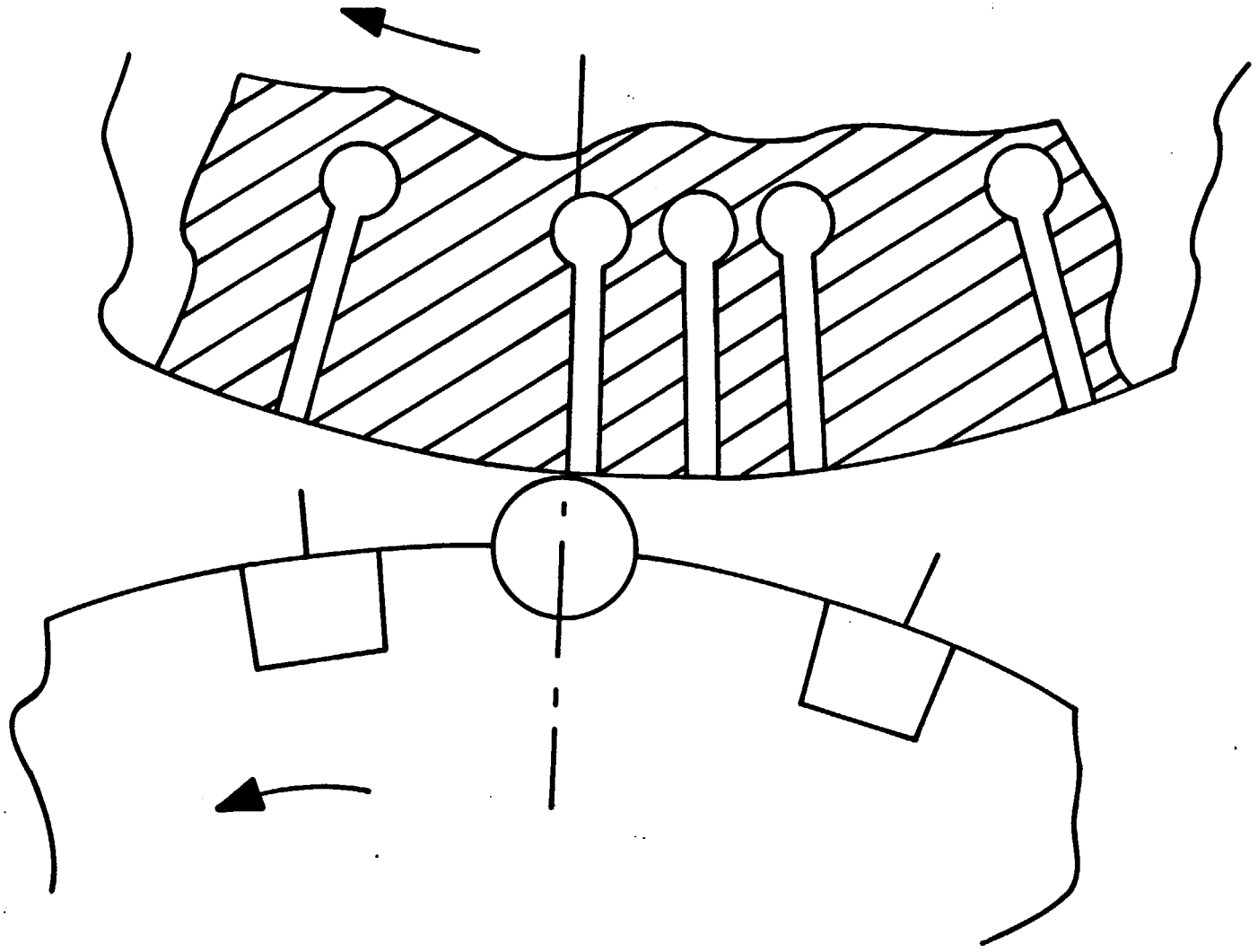
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000



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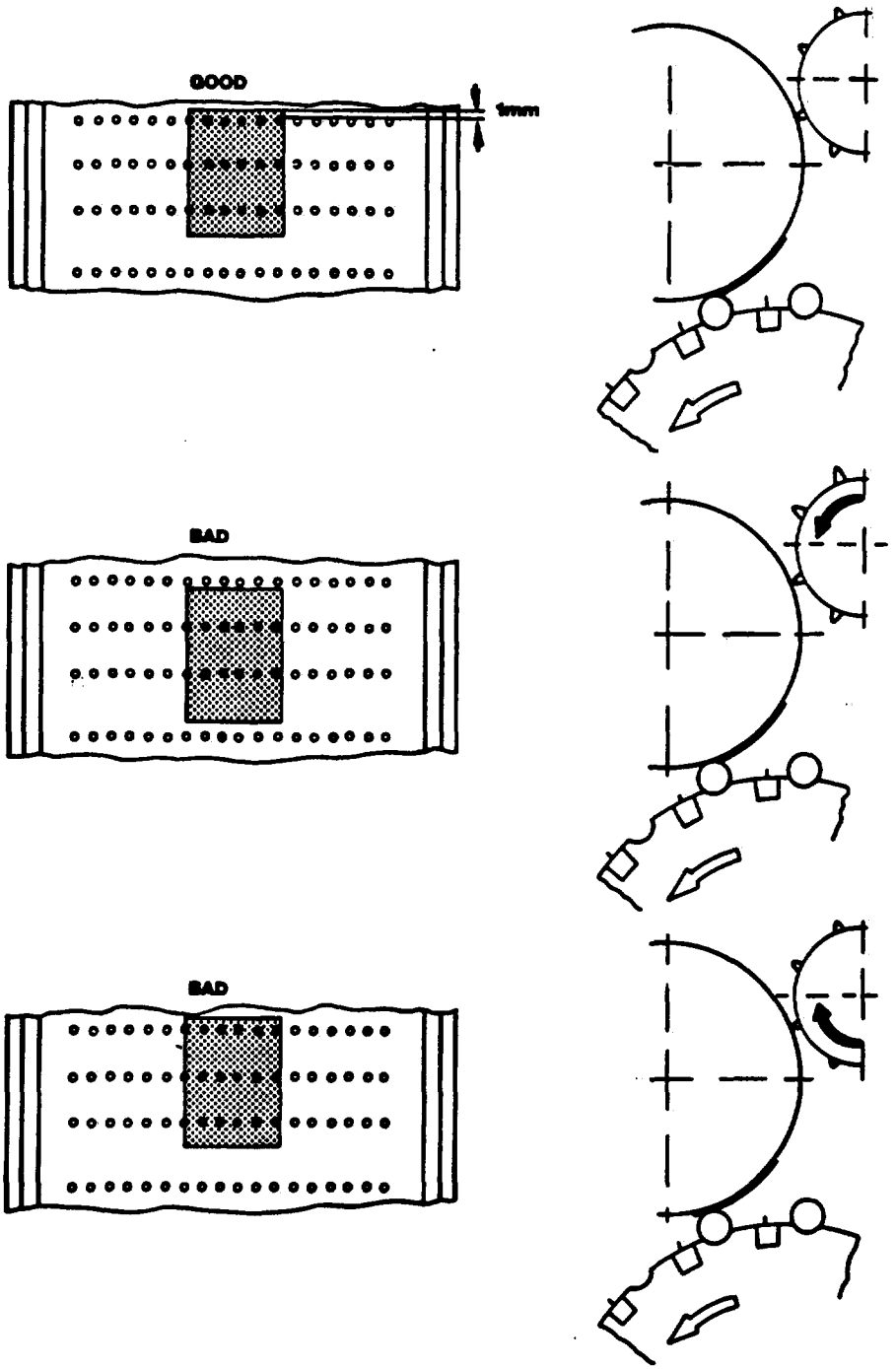

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

SKIP GAP GUMMER

Timing the Transfer Roller to the Cork Knives

If the cork knives are retimed with reference to the cork drum inserts, the gum pattern must also be moved by the same amount.

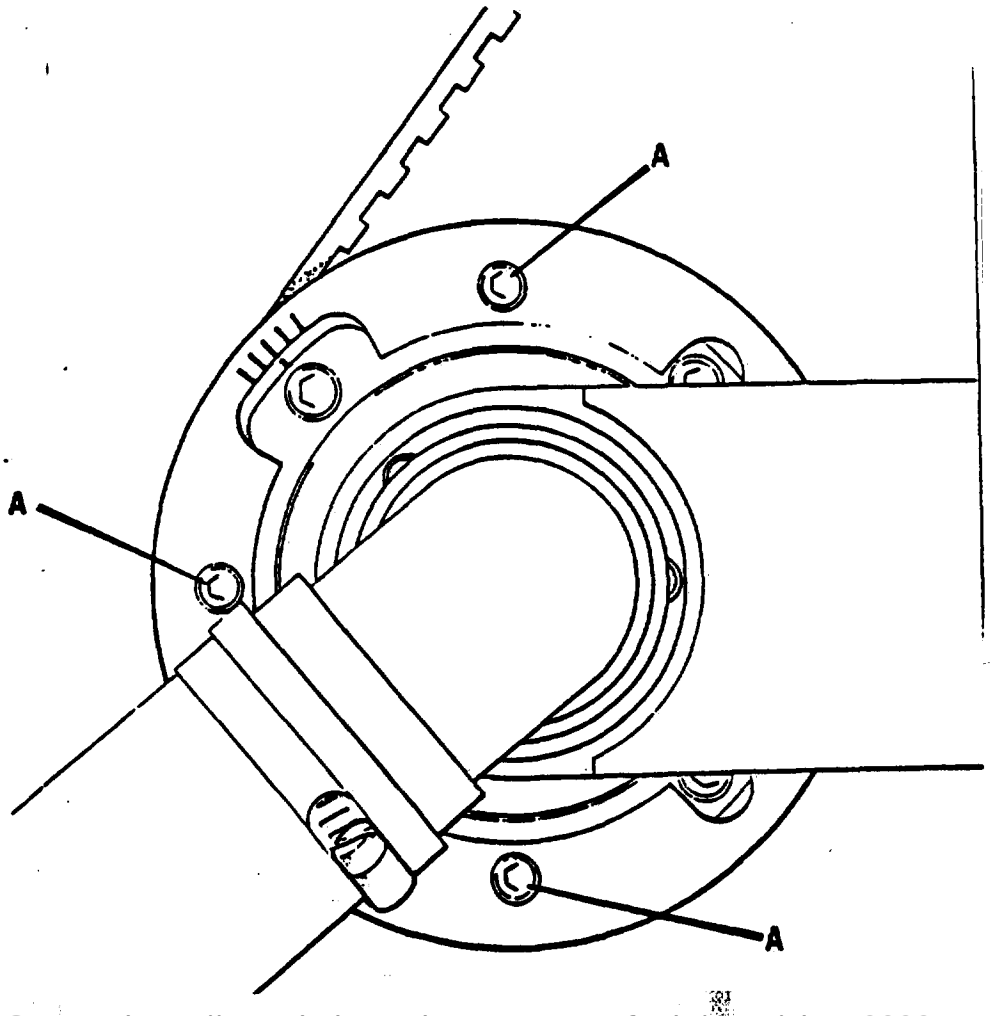
(a) At the final cut drum release the screws clamping the drive pulley to the pulley support A.

(b) Turn the pulley through a small angle without turning the drum. A mark on the inside face of the pulley support can be compared with a group of marks on the pulley flange to judge the angle through which the pulley has been advanced or retarded.

Setting the Rollers to the Nozzle

(a) Use feeler gauges to determine the clearance between the transfer roller and the gummer nozzle and also between the gum roller and the gummer nozzle. The desired clearance is 0.01 in (0.25mm) at both rollers.

(b) To reduce or equalize the clearance, withdraw the gummer and release the grubscrew locking the eccentric pin in the spindle block. Turn the pin as required to set the position of the gummer nozzle.



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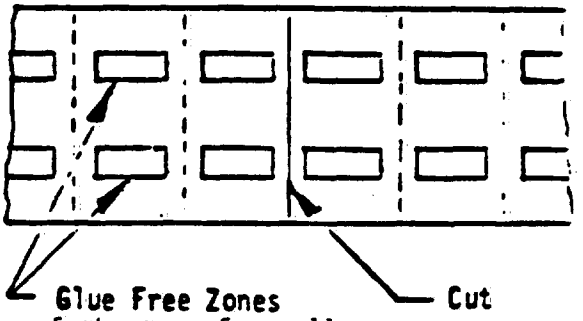
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

MAX S
GLUING UNIT, "SKIP-TIP" GLUE APPARATUS

Setting of Gluing Pattern

Notes: A. Before setting the gluing pattern it is very important, that the tipping drum and knife roller has been set properly (see section 6 of operating instructions).

B. It is very important that the tipping knife cuts the tipping paper exactly in the center between the glue free zones.



1. Loosen clamping screw of the transfer roller.
2. Turn the glue roller together with the transfer roller to desired position and lock clamping screw again.
3. Run machine and check pattern.
4. Repeat if necessary steps 1, 2, and 3 until your cut is exact centered between the glue free zones.
5. When the gluing pattern is in the right position, mark intersection point of tipping knife on tipping drum. See sketch.
6. Loosen screw of glue roller fastening disk, align its mark with mark on glue pot and tighten screw again. Follow the same procedure with end piece of transfer roller shaft and align its mark with transfer roller clamp mark.

Note: Rotation of glue roller fastening disk DOES NOT change location of glue pattern.

7. For setting pattern axially see section 6, 4.3 of operating instructions. Same as regular tipping.

Note: When the machine is stopped, the stirrer motor drives the glue roller at a speed which is NOT equal to production rates thereby causing a smeared pattern on the first assemblies at start-up. These cigarettes are rejected automatically.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Skip-tip Gluing (Special Equipment)

Skip-tip gluing is only required when using preperforated tipping material.

Adjustments

a) Basic requirements are that the knives are set up correctly relative to the tipping material roller.

b) The gluing pattern on the tipping material must be in a certain position relative to the knives (see sketch).

c) To visually recognize the gluing pattern on the paper, color the glue, using a die which is soluable in water. A perfect gluing pattern can only be recognized when the machine is running at production speed.

d) On hand of the gluing pattern, adjust the glue roller until cut (C) is exactly between two glue-free zones (see sketch). The adjustment should be made tooth by tooth.

Marking the setting

a) Hand-turn the machine until pin (7.1) at the transfer roller spur wheel corresponds with the intersection of the gluing roller (see sketch).

b) Adjust disc in front of the gluing roller so that the marking coincides with the pin.

c) When re-installing a glue roller make sure that the markings always coincide. The position of the gluing pattern is then always correct.

Fine Adjustment

By turning knurled screw (13), the gluing pattern relative to the cut (C) can be shifted slightly so that it is exactly between two gluing patterns.

The knurled nut should always be centralized to be able to make adjustments both ways.

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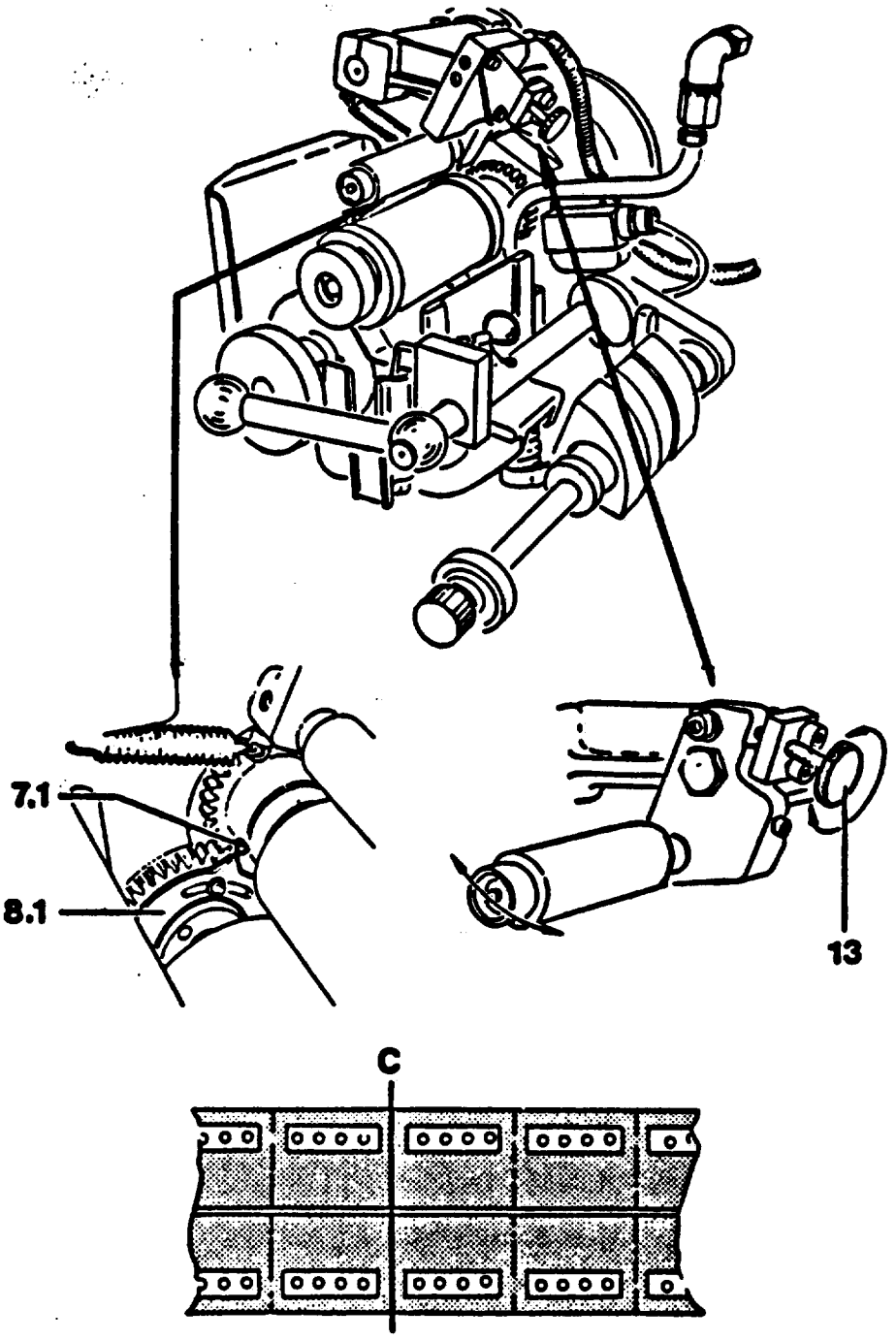

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

MAX S
"SKIP-TIP" GLUE APPARATUS

Operating Instructions:

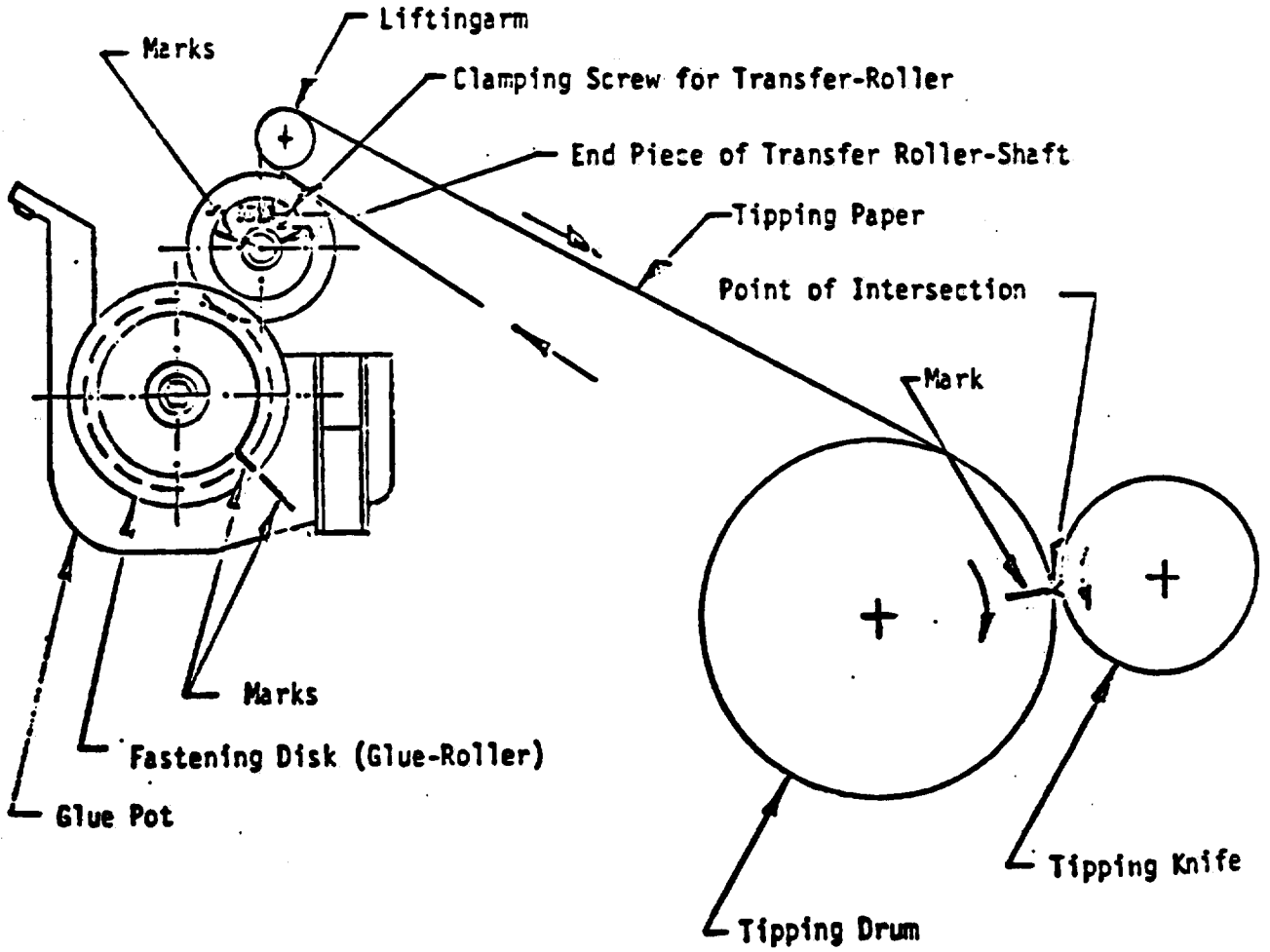
Positioning Glue Pot after cleaning or at start-up the following sequence has to be observed:

1. Turn power on and make the machine ready to run, but DO NOT start stirrer motor.

2. Turn machine by hand (observe that the transfer roller is turning counterclockwise) until one tipping knife corresponds to mark on tipping drum (see sketch).

3. Install glue-pot with glue roller in place. Care must be taken, that the marks of fastening disk and glue pot coincide.

4. Start stirrer motor. The machine is now ready for production.



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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Grinding the Gluing and Transfer Rollers

Worn rollers do not produce a perfect gluing pattern on the tipping material. The rollers can, in this case, be reground. Make sure that the diameters of the rollers are in the ratio of 2.3 to maintain the correct speed ratio.

The values from the table below should be adhered to:

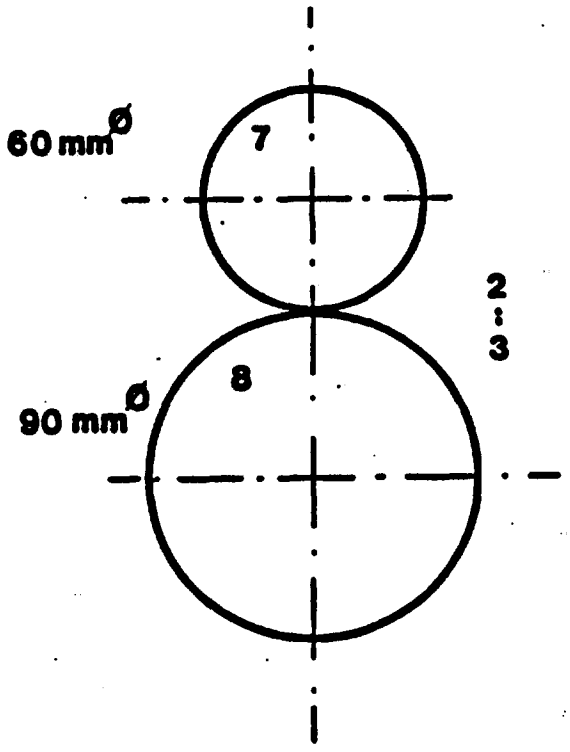
	Diameter (new)	Min Diameter	Recommended diameter reduction	Potential Accuracy
Gluing roller (8)	90mm	89.2mm	0.09mm	0.01mm
Transfer roller (7)	60mm	59.5mm	0.06mm	0.005mm

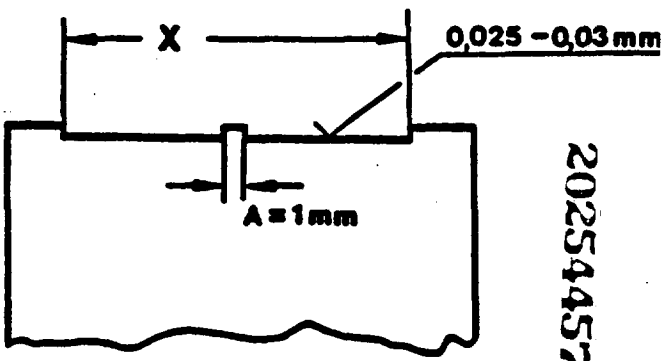
The gluing zone should be ground to a depth of 0.025 to 0.030mm.

The 1mm wide center ridge "A" must be retained.

Gluing zone "X" should measure tipping material width plus 1mm.

If the roller diameter drops below the fixed minimum the rollers are unusable since the gear wheel play will then be too small.





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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

MOLINS
Machine Company Inc

February 23, 1983

DEFINITION OF DIMENSIONS ON PA85 GUM ROLLERS
AS USED BY PHILIP MORRIS, U.S.A.

Dimension "A" equals the width of the double length tipping paper plus 3mm. The 3mm figure allows 1.5mm of tipping paper to extend over the extreme ends of the glue roller grind area thus assuring that gum will be applied to the ends of the tipping paper even if there is paper wander. The Molins or normal standard is 1mm each end.

Dimension "B" equals the dry line which is where the final cut knife on the PA85 cuts the double length cigarette into two individual cigarettes. The Molins or normal standard is 1mm. Philip Morris USA uses .5mm.

Dimension "C" equals one-half "A" dimension (double length tipping paper) plus 1.5mm overlap minus "B" dimension or the dry line.

Dimension "D" equals the normal step where additional gum is applied to assure good adhesion to the filter tip. If no dimension "P" is used (which would be the standard for all companies except Philip Morris Richmond), the "D" dimension equals the length of the additional glue step (reference "K" dimension).

Dimension "E" equals the width of the patch or the band of the skip gap.

Dimension "F" only relates to a dimensional figure from the end of the gum roller, but if used in conjunction with Dimension "M", positions the band relative to the tipping paper or filter.

Dimension "G" is the same relationship as Dimension "F".

Dimension "H" equals the break in the band (Dimension"E") to allow for the tipping paper lap and proper glue joint.

Dimension "I" is in relationship to Dimension "H", i.e. one-half from centerline.

Dimension "J" is the depth of the break and is normally .0015".

Dimension "K" is the additional glue step (reference Dimension "D"). at the cigarette/filter joint, i.e. this is where additional gum or adhesive is applied to the tipping paper to ensure proper adhesion between the filter and the cigarette and to avoid air leaks. This step is normally .00025" and is in addition to the normal glue application across the face of the gum roller (Dimension "L").

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

MOLINS
Machine Company Inc

February 23, 1983

DEFINITION OF DIMENSIONS ON PA85 GUM ROLLERS
AS USED BY PHILIP MORRIS, U.S.A. (continued)

Dimension "L" is the normal step on the glue roller face which establishes the amount of adhesive or gum that is applied to the tipping paper. The normal dimension is .00125".

Dimension "M" basically refers to the starting point from which the glue roller pattern is machined. It is much easier to start from the end of the glue roller than to pick up the center and move in either direction. It is very important in establishing centering of the pattern on the roller.

Dimensions "N" and "P" relate only to a groove which is a Philip Morris USA standard to ensure an additional application of adhesive or gum at the overlap area of the tipping paper on the cigarette.

GENERAL

The normal procedure for manufacturing a gum roller is to make a blank. We in Molins USA use the Blank SKU 14769 which varies from the Molins London design in that it is a fabrication made up of a gear, the gum roller body and a bushing. The standard Molins London type is made from one piece of material whereas the gear and the bushing are cut out of solid material. They are normally in the part number range of 49079-VAR. We in Richmond prefer to use our design as the scrap rate is lower and manufacture is more economical.

The normal procedure for establishing a PA85 gum roller for skip gap application would be to fill in the attatched patch drawing and supply to Molins for conversion and application to the SKU 13806-VAR. glue roller drawing. At this point, customer would be advised what variables had been allocated to his particular patch which was based on the drawing provided.

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Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

C. Cigarette Manufacture

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

PA8 ROLLING PLATE

Set Rolling Plate to Cork Drum:

1. Loosen 13mm set bolt on vertical adjustment and 10mm set bolt on radial adjustment.
2. Place 7.5mm rod between cork drum and rolling plate. (.5mm less than cigarette diameter.)
3. Adjust, using vertical and radial adjustment, to a snug fit on roll-plate lead-in and exit.

Center Roll Plate Fingers on D.E. Closer:

1. Loosen two screws on drying drum and remove valve. Loosen 4-5mm and remove drying drum.
2. Remove plug aligning drum cowl.
3. Loosen 3-6mm lock bolts.
4. Pull roll plate to the front and find the smallest finger-pocket clearance and set roll plate finger with equal clearance.
5. Lock bolt.
6. Replace drum, valve and cowl.
7. Time drying drum to take off drum.

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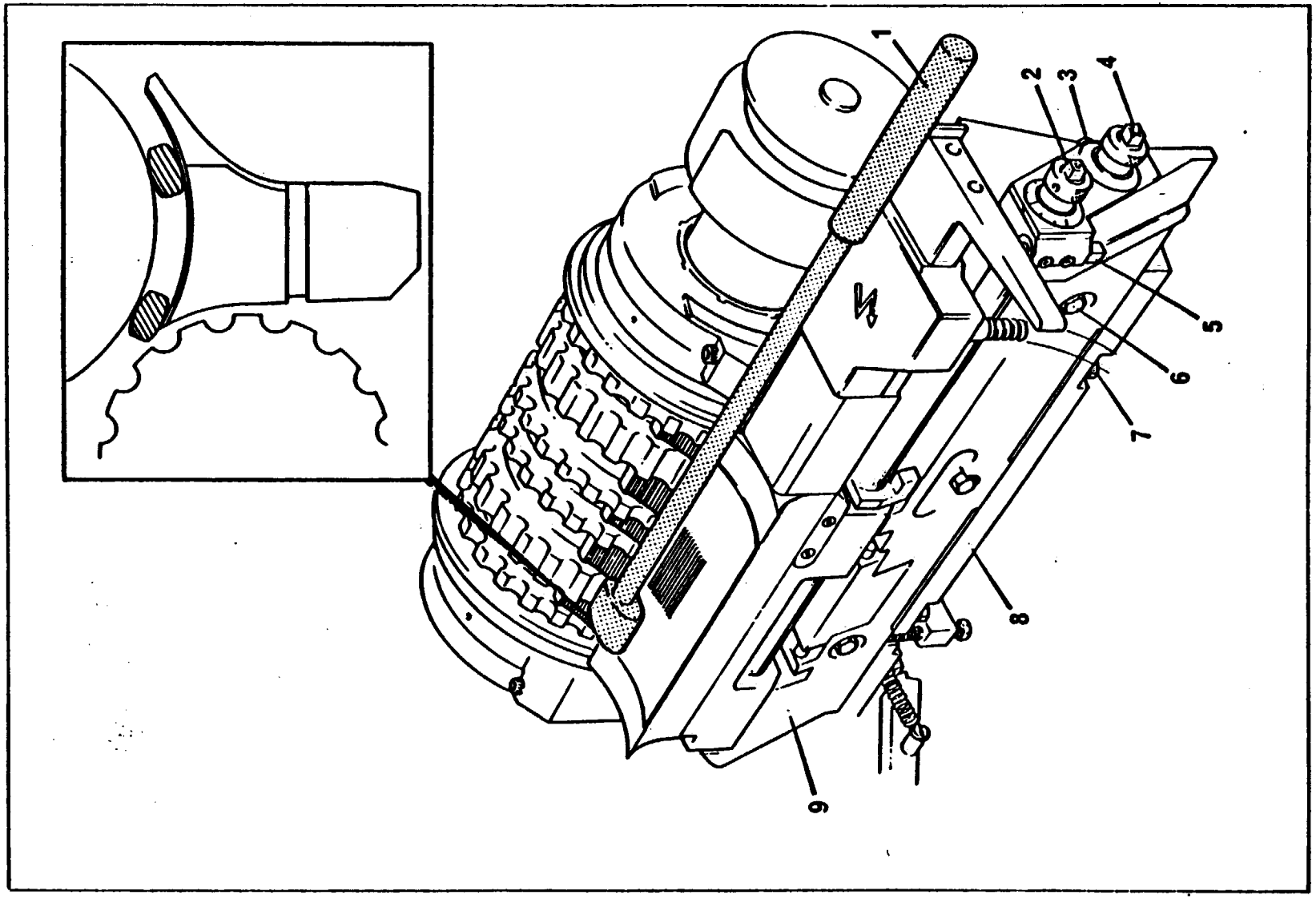
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000



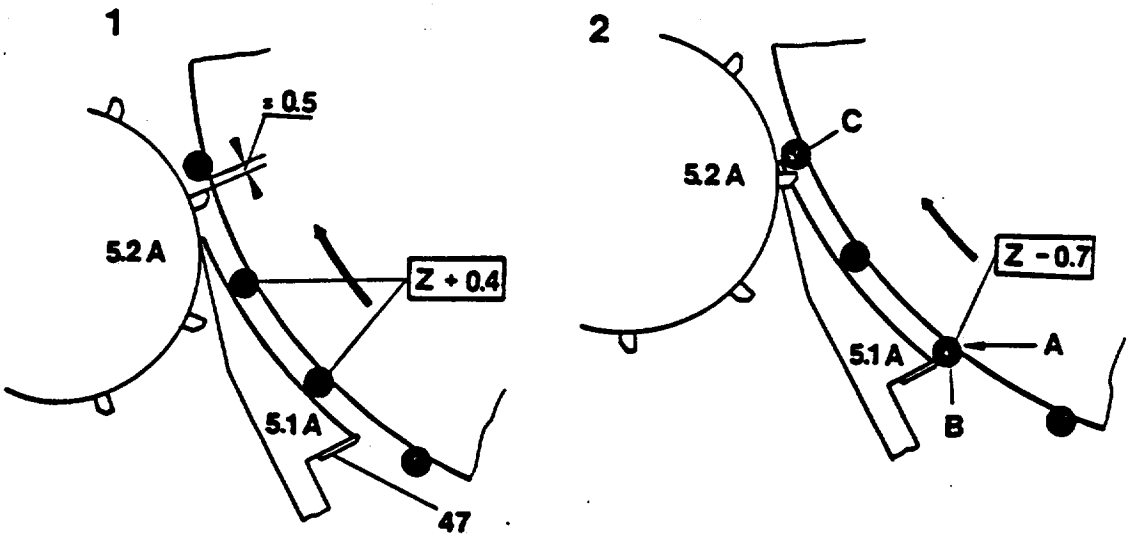
Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000

Set Roll Block to Rolling Drum:

1. Place two flutes of rolling drum centered in the roll block.
2. Check for cleanness and proper heat.
3. Set roll block to 2-8.0 or 2-8.1mm rods. (4-6mm allen or 4-13mm bolts).
4. Loosen bolts then snug. Tap with brass hammer on rolling block housing for a snug rod fit. Lock bolts.
5. Recheck with rods.

Set Lip to Rolling Drum:

1. Turn rolling drum to where there is a flute-lip centerline.
2. Place 7-3mm rod between lip and flute. Loosen 4-3mm allen and place .008 feeler gage on each side between rod and lip. Pry up for a feeler gauge fit. Lock lip.
3. Recheck.



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D. Equipment

Source: https://www.industrydocuments.ucsf.edu/docs/qlmm0000